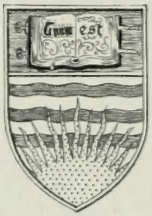
EXPERIMENTAL PSYCHOLOGY



AN INTRODUCTION TO EXPERIMENTAL PSYCHOLOGY IN RELATION TO EDUCATION

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IN RELATION TO EDUCATION

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PREFACE.

In this little book an account is given of a number of psychological experiments which bear directly upon educational problems and on the work of the teacher in the school. All the experiments described can be carried out without any apparatus except such as can easily be made with pen and paper. The need for such a book has been for some time felt by many teachers and by those engaged in the training of teachers.

There is an unfortunate impression abroad that experimental psychology necessarily involves complicated and expensive apparatus. For some types of experiments this is of course the case. But, fortunately for the educationist, many of the experiments which are of the greatest interest and value for his special work have no such need.

No text-book can take the place of a living teacher, yet it is hoped that this book will be of value to the private student. He should be able to carry out all the experiments here described in his own room, and, after gaining an intelligent grasp of the principles and methods discussed, he will be able to apply many of them also in the schoolroom, with results interesting to himself, and very illuminating as regards the mental characteristics of his pupils. Anything of this nature which helps to keep a teacher from becoming a slave of routine, and which enlivens his interest in the mental life of each individual pupil, is to be welcomed as a means of raising the whole level of his work.

I have tried to avoid assuming a previous knowledge of psychology, but the reader who has no such knowledge is strongly advised to read in connection with this book some general introduction to psychology.[1] Without this many points must necessarily remain obscure. Frequent suggestions for appropriate reading will be found throughout this book.

Whilst I have constantly kept in view the private student or the school teacher, it is hoped that this book will also prove serviceable as a handbook in connection with class work.

In the course of some years' experience in teaching experimental psychology to Training College students, the writer, like others in similar positions, has felt the lack of a suitably small and simple text-book. The crowded time-table of the modern Training College does not as a rule admit of a long course in experimental psychology, and during the hours which are available it is desirable that the students should be occupied, as far as possible, in the actual carrying out of experiments in class under the oral instruction of the teacher, or in discussing their results. The dictation of elaborate notes, as to the full significance of the methods and results of the experiments, and of the theory underlying them, may leave inadequate time for the carrying out of the experiments themselves. Yet without some supplement of oral instruction the most careful student may fail to master the problems at issue. Given a suitable hand-book, the student's own note-book can be kept for the results of the actual experiments in which he takes part, and for his

[1] For example: G. F. Stout, *Groundwork of Psychology*; Loveday and Green, *Introduction to Psychology*; Lloyd Morgan, *Psychology for Teachers*; B. Dumville, *Child Mind*; L. Brackenbury, *Primer of Psychology*.

observations upon his own mental processes and characteristics.

Most of the experiments described here are such as have been found suitable for classes of from twenty to thirty students.

I venture to suggest that the book may also be useful to students who are undergoing a course in general psychology but who are receiving no instruction in experimental psychology. The importance of some experience of experimental work as a supplement to the study of theoretical psychology is now widely recognised by the highest authorities. Some indeed contend that the study of psychology should begin with a course in experimental psychology.

The special value of experimental psychology for teachers will be more fully discussed in the introductory chapter.

In a book of this nature the writer inevitably owes much to other and earlier workers. I am indebted to many of those to whose writings references are made in the footnotes and in the bibliography, and especially to the training received under my former teachers at Cambridge, Dr. C. S. Myers and Dr. W. H. R. Rivers.

My best thanks are also due to my colleague, Dr. J. Davidson, Master of Method in the Training College, Dundee, for a critical reading of the typoscript, from the point of view of the school teacher.

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INTRODUCTION.

The Value and Aims of Experimental Psychology.[1]

1. The most definite value of experimental psychology is that it increases our knowledge of psychological facts. and laws. Although the science is still young, it has already accumulated a large number of important facts. Some of these doubtless appear to have little bearing upon the practical work of the school. But we cannot split the mental life into sections and say that we, as teachers, are concerned with this part, but not with that. Consequently we cannot entirely separate educational from general psychology. At least educational psychology is dependent on the advance of general psychology.

For a complete science of the mind we need researches into all the various states and activities of the mental life. Thus the educator is indirectly interested in many psychological problems which at first sight appear to have no connection with his special pursuit. A better knowledge of these problems will bring him to a clearer understanding of mental process in general, and this he should be able to apply in dealing with the young minds under his special care.

[1] In connection with this chapter the student should read the opening chapter or chapters of some book on general psychology, such as those recommended in the Preface.

2. It must, however, be recognised that, from our present point of view, the chief importance attaches to those experimental results which have an immediate bearing upon education. These are already by no means inconsiderable, as I hope the reader will see from a further study of this book and from a perusal of works devoted especially to the results of investigations in educational psychology.[1]

The literature devoted to new researches of this nature is steadily increasing,[2] and one of the chief values of a course in experimental psychology is that the student is thus enabled to understand such literature more easily and to appreciate it better. His training also will give him greater skill in sifting the wheat from the chaff: for it must be admitted that a good deal of work which shows faulty method and immature and hasty conclusions still succeeds in getting into print.

3. In the third place, and still more relevant to the purpose of this book, the student in actually carrying out experiments himself gains a much more vivid realisation of the nature of the mental processes involved. Systematic and repeated study of these often reveals to the student facts about his own mental life which have completely escaped the chance observations on which he has previously relied. Comparison with the results gained by others may also show him that his own mental experiences are marked by definite individual characteristics, and must not be regarded as absolutely typical.

Further, the exercise in self-observation which experi-

[1] See Bibliography.

[2] To speak only of British journals, one—*The Journal of Experimental Pedagogy*—is largely devoted to such researches, and important papers bearing directly upon educational problems frequently appear in the *British Journal of Psychology*.

ment gives leads to greatly improved powers of introspection, and this again enables one to obtain a more accurate acquaintance with one's own mental life. Now it is upon this self-knowledge and upon the power of self-analysis that our understanding of others ultimately depends—even our understanding of children.

This particular value of a course of psychological experiments is especially obvious with reference to those experiments (of which several examples will be found in this book) in which the student tries to put himself into a position similar to that of the child in learning.

4. Lastly, the teacher who has had some training in experimental psychology will be better fitted to carry out investigations, if only very simple ones, among the children of his own class.

A word of caution is needed here. Mental tests are much more difficult to manipulate and interpret than may appear at first, and for first-rate reliable research work a long and thorough training is needed. Nevertheless a teacher with a "bent" for scientific method, who has gone through a course in experimental psychology such as that suggested in this book, may be able, through applying simple tests and experiments to his own class, to glean information about the mental characteristics of his pupils which will be of great interest to him and of no little value for his teaching work.

The teacher of the class, indeed, is in some respects in a better position to carry out certain mental tests upon his children than is the professional experimental psychologist. He knows his children well, the disturbance caused by the entry of a stranger into the class is avoided, and in so far as the material used in the experiment resembles that given in ordinary school lessons his presentation of it may be more uniformly efficient than

that of the experimentalist who has had no experience in teaching children.[1]

In his own school-teaching days the present writer found such tests possible with very little interruption to class work, and the teacher may count upon his pupils entering into the novel and mysterious experiments with keen interest, if they are properly approached. Doubtless the ordinary work of the class allows little time for such work. But some of the suggested tests can be done in little more than a quarter of an hour, and longer can probably be spared for some of the others if the teacher is content to attempt only one or two in the course of a term.

It may sometimes appear that a psychological research has only proved to be an elaborate and painstaking method of demonstrating the obvious. But it is often of great value to discover the reasons even for conclusions which have been previously accepted as self-evident. Furthermore, some things which have been thought to be obvious by many educationists have been shown by experiment to be false, so that it is not without value to have other equally "obvious" beliefs scientifically demonstrated.

Again, even if a certain experiment professedly deals with facts which are already known to us, the actual performance of the experiment itself is often illuminating to a surprising degree.

Finally, I should like to emphasise the fact that the chief aim of this little book is to encourage the actual participation in psychological experiments on the part of the student himself. The subsequent application of some of the experiments to school children, though of considerable

[1] Cf. the remarks of Mr. C. Burt as to the reliability of the experimental work of school teachers in various kinds of mental tests, *Journal of Experimental Pedagogy*, Vol. I., p. 104.

interest and value, is not essential to the main purpose of the course.

Plan and Method of the Book.

In Part I. will be found detailed instructions for carrying out the various experiments, the necessary material being given here. The student should perform each experiment completely before turning to the discussion of the results of the experiment and their significance, which will be found in the corresponding chapter of Part II. Thus Chapter I., Part II. discusses the theoretical and practical significance of the experiments of Chapter I., Part I. Chapter II., Part II. discusses the experiments in Chapter II., Part I., and so on. The chapters of Part II. also discuss the application of the experiments in school.

It has been thought well to keep separate the instructions for the experiments and the discussion of the results, as it will then be clear to the student exactly how much he must read before performing an experiment. In a few cases it is important that the student should not have even a momentary glance at the discussion of the results before doing the experiment, otherwise it will be difficult for him to avoid being influenced by suggestion. When it is desirable for the student to know the object of the experiment before doing it, the necessary information is given with the instructions for carrying out the experiment.

It is also hoped that the division into two parts will facilitate the use of the book for class purposes.

Not all the experiments are intended for use in school. The purpose of a few is simply the instruction of the student who performs the experiment. This applies more particularly to some of the earlier experiments.

Throughout the course the student should make a special

point of writing down and keeping for future reference his observations upon his own mental processes as observed in the experiments, not counting anything too trivial to be noticed. Even the apparent failures should be noted. The private student should not be disappointed if occasionally he forgets, or misunderstands at first, some part of the instructions and so fails to carry out the experiment properly. This often takes place with beginners, even in a psychological laboratory and under the supervision of an instructor. But, fortunately, if the nature of the error is detected and its corresponding effects traced, such a failure may prove as instructive as, and occasionally even more instructive than, the proper carrying out of the experiment.

It is not as a rule necessary that the experiments should be done in the order in which they are arranged; but the experiments on Imagery should be performed before those on Memory, and the Memory experiments should be taken in the order indicated.

PART I.

CHAPTER I.

ASSOCIATION AND REPRODUCTION OF IDEAS.

Experiment I.

Cover up all the words in the list below with a piece of paper. Move the paper so that the first is exposed, and then write down at once the first word or phrase suggested by this word. Make an effort to note the very first word suggested, and do not hesitate to write that down even if it seems to have absolutely no connection with the given word. Proceed thus with each of the words in the list.

river	book	friend	bicycle
station	newspaper	house	good
ball	song	doctor	train
dog	martyr	green	town
organ	child	sadness	sea

Add any observation you can as to the exact way in which the idea occurred to you. For example, did you mentally picture the things of which you thought.

For a discussion of the results of this experiment and their significance see Part II., Chapter I., p. 86.

CHAPTER II.

IMAGERY.

Experiment II.

Types of Images.—The whole of the instructions for this experiment should be read before the experiment is begun. It should be noted that the word image has a very wide significance in psychology. It includes not only the mental picture we get when we close our eyes and try to recall the appearance of something, but also the corresponding mental reproduction of a sound, or of a smell, or of a sensation of touch, taste, or movement.[1]

Think of a troop of soldiers marching.

(*a*) Can you get a mental picture (*visual image*) of them? Is the image clear (i) in form, (ii) in colour? Would you describe the image as very vivid, vivid, clear, only moderately clear, vague, or very vague?

(*b*) Can you hear mentally the sound of the marching, *i.e.* can you get an *auditory image*? Does the sound occur with its appropriate rhythm? Would you describe this image as very vivid—clear—etc.?

(*c*) Can you mentally recall the "feel" of marching (*motor image*)? Would you describe this image as vivid, or vague, etc.?

[1] On the nature of Imagery see further, Stout, *Groundwork*, Chapter X.; Dumville, *op. cit.*, Chapter V.; Loveday and Green, *op. cit.*, Chapter XI.

Try similarly whether you can get

(*d*) *A touch image* of the sensation produced by touching velvet or emery-paper;

(*e*) *A taste image*, say of an orange, or of coffee;

(*f*) *A smell image* of the coffee, or of a rose;

(*g*) *A temperature image*, of the sensation produced by the heat of a fire, or by touching ice;

(*h*) *A pain image*, of the pain of a pin-prick, or of any pain you have recently experienced.

The student should repeat the tests, using the following imagined objects for the respective kinds of imagery:—

(*a*) A house, a friend.

(*b*) The howling of the wind, a friend's voice.

(*c*) The movement of the tongue and lips in saying "God save the King," and of the fingers in writing it. (Care must be taken not to move the lips or fingers while trying to get these motor images.)

(*d*) The touch of a blanket, or of marble.

(*e*) The taste of sugar, and of salt.

(*f*) The smell of tar, and of gas.

(*g*) The heat of a strong sun, the cold of a piercing wind.

(*h*) Toothache, a burn, or the pulling of the hair.

The student should now be able to draw some conclusions as to the comparative vividness of the different types of imagery in his own case.

Experiment III.

Facility of Imaging tested by Speed.—Read the instructions right through before starting the experiment.

If possible get a friend to time you in this experiment.

(*a*) First take two minutes and write down the names

of as many objects as you can get a clear *visual* image of in that time.

(*b*) Then take four minutes and write the names of all the sounds of which you can get a clear *auditory* image in that time, *e.g.* dog's bark, sea roaring, piano playing, etc.; but only write *one* word to represent each image.

(*c*) Lastly take two more minutes and write down again the names of as many objects as you can *visualise* in the time. Thus you will have given four minutes to each type of imagery.

If you are much more ready at any one kind of imagery the corresponding list is likely to be appreciably longer than the other. Take care to be sufficiently strict, and only write down the names when you have had a clear visual or auditory image of the object.

Experiment IV.

Poetry and Imagery.—Read over the following poem at your usual pace:—

"Five years have past; five summers, with the length
Of five long winters! and again I hear
These waters, rolling from their mountain-springs
With a sweet inland murmur.—Once again
Do I behold these steep and lofty cliffs,
That on a wild secluded scene impress
Thoughts of more deep seclusion, and connect
The landscape with the quiet of the sky.
The day is come when I again repose
Here, under this dark sycamore, and view
These plots of cottage-ground, these orchard-tufts,
Which at this season, with their unripe fruits,
Are clad in one green hue, and lose themselves

Among the woods and copses, nor disturb
The wild green landscape. Once again I see
These hedgerows, hardly hedgerows, little lines
Of sportive wood run wild: these pastoral farms,
Green to the very door; and wreaths of smoke
Sent up, in silence, from among the trees!
With some uncertain notice, as might seem,
Of vagrant dwellers in the houseless woods,
Or of some Hermit's cave, where by his fire
The Hermit sits alone."

Now note as far as possible the images you had in the course of reading. To what extent do you think that they affected your appreciation of the poem?

Repeat the same test with the following verses: here a great variety of images is possible.

"Beneath those rugged elms, that yew-tree's shade,
Where heaves the turf in many a mouldering heap,
Each in his narrow cell for ever laid,
The rude forefathers of the hamlet sleep.

The breezy call of incense-breathing morn,
The swallow twittering from the straw-built shed,
The cock's shrill clarion, or the echoing horn,
No more shall rouse them from their lowly bed.

For them no more the blazing hearth shall burn
Or busy housewife ply her evening care:
No children run to lisp their sire's return,
Or climb his knees the envied kiss to share.

Oft did the harvest to their sickle yield,
Their furrows oft the stubborn glebe has broke;
How jocund did they drive their team afield!
How bowed the woods beneath their sturdy stroke!"

Note especially the extent to which you had all the various images which might be suggested here, not only visual, but auditory; or images of smell ("incense-breathing morn"), of touch (the children climbing on the knee), of movement (the ploughman driving his team), etc.

For a discussion of the results of Experiments II., III., and IV. and their significance see Part II., Chapter II., p. 95.

CHAPTER III.

ATTENTION.

Experiment V.

The Concentration of Attention.—(*a*) Take some common object like a pen or pencil and try to concentrate your attention upon it for one minute, getting a friend to tell you when the minute is up. The purpose is to discover the number of times your attention wanders from the object in the course of the minute.

Whenever your attention does so wander, indicate it to your partner by the movement of a finger or of a pencil held in the hand. Your partner should count the number of such signs and note it down without telling you, for the present.

Try to hold the object itself in mind, simply the object as it is. Do not think things *about* it. The subject should take special care to indicate the slightest fluctuation of attention away from the object. Of course the attention may wander from the object even when the *vision* is still concentrated upon it.

(*b*) Again, attend to the object for a minute, but this time ask yourself questions about it, *e.g.* as to its size, the proportions of the length to the thickness, the exact shade of the colour, the material of which it is made, the flaws in the making, etc. Indicate as before the number of fluctuations of attention from the object or ideas immediately connected with it. You can now change rôles with your partner.

As always, you should write down as much as you can in the way of introspective remarks immediately after completing the experiment and before turning to read the discussion of the results in Part II.

For a discussion of the results of this experiment see p. 100.

Experiment VI.

The Control of Attention.—The following experiment may be regarded as the converse of the foregoing. There we were concerned with keeping something in the mind, here with keeping something out of the mind.

(*a*) Choose a topic of some interest to you; we will suppose it is the holidays just past.

Now for one minute try to avoid thinking of those holidays: if the idea does come into your mind try to put it out as quickly as possible. But do not fix upon any special topic upon which you will think. Let your mind wander freely.

Get your partner to time you; hold a pencil in your hand and whenever you do think of the forbidden topic raise the pencil. Your partner must count the number of times you raise the pencil within the minute, and he should note this down without telling you for the present.

(*b*) Now take another minute, and as before try to avoid thinking of the holidays. But this time choose another topic which has some interest for you, let us say your future career. Try to concentrate your mind upon this, debating what you shall do, and the how, when, and where of your future movements.

As before, let your partner time you and count the number of times your mind slips back to the holidays, which again you will indicate by the raising of the pencil.

Now compare the number of times the idea of the holidays occurred to you in the first and second experiments.

Subsequently your partner should do the experiment, you timing him meanwhile. It may be well to reverse the order of procedure, having first the minute in which some definite interesting topic is thought of, and second the minute in which the subject merely tries to avoid the forbidden topic.

Strictly we should time the *duration* of the thought of the holidays in the mind, instead of being content with counting the number of times it recurs: for if the idea remains continuously in the mind for a number of seconds in the course of either minute, this will evidently reduce the probable number of times of the recurrence of the idea in that minute. It would, however, scarcely be possible so to time the duration of the thought, for the very act of indicating that I was now thinking of something other than the holidays would recall the holidays to me. We must therefore be content with a cruder means of measurement.

For a discussion of the results of this experiment see p. 101.

Experiment VII.

The Division of Attention.—Is it possible to carry on two mental operations at once? This can be put to the test thus:—

(*a*) Count aloud the odd numbers, 1, 3, 5, 7, etc., as fast as you can, and see how far you can get in one minute. Note the number down.

(*b*) Now write down in order the letters of the alphabet as fast as you can. When you get to Z begin at A again and go on until a minute is up. Count the number of letters written down.

(*c*) Now try to perform both operations at once, counting the odd numbers aloud and at the same time writing down the letters of the alphabet. Do this for one minute. Compare the number of letters written in this minute with the number written before, and compare the number of figures counted with those counted in test (*a*).

For a discussion of the results of this experiment see p. 102.

Experiment VIII.

The Attraction of Attention.—(*a*) Read over the following words at the rate of one per second to a friend (or to a class) asking him to remember as many as he can and to write down all he recalls when you have finished the list.

To ensure greater accuracy as regards time it would be well to make use of a watch. The watch should be held to the ear until the four-beat rhythm is clearly apprehended. Still keeping the watch to the ear the words can now be read out as described, each word coming at the first of a group of four beats. Such a group is usually equivalent to about one second in duration.

Read the words quietly with the exception of those printed in capitals, which should be read very loud.

Cage, fan, bench, SPOON, glove, nail, cloud, reel, HEART, camp, brain, foal, POST, desk.

(*b*) Read out the following words similarly at the rate of one per second to a friend (or to a class), asking him as before to write down all he can recall when you have finished. This time read all the words out in a fairly loud tone except those in italics, which should be whispered.

Man, key, sponge, *bat*, cake, book, road, smoke, *fox*, twig, curl, pen, *tub*, wool.

For a discussion of the results of this experiment see p. 105.

CHAPTER IV.

ECONOMICAL METHODS OF LEARNING.

Experiment IX.

The Learning of Poetry.—If one has to learn a poem, say of twenty or thirty lines, is it better to learn two or three lines at a time or to read the whole poem through over and over again? Most people unhesitatingly pronounce in favour of the first method. We proceed to put the question to experimental test. Briefly, the method is to spend an equal amount of time in learning two poems of equal length and difficulty, one by the whole and the other by the sectional method, and then to compare our knowledge of one poem with that of the other.

One must first secure two poems or parts of poems of approximately equal difficulty. It is of course not easy to make sure of this; but if a student doubts the equality of difficulty of Pieces A and B on pp. 20 and 21 he can easily perform the experiment on another subject and get him to substitute B for A and vice versa. Or he can repeat the experiment on himself with the other selections at the end of this chapter. Judging from experiments upon the writer's own students the two pieces given seem to be on the average of almost exactly equal degrees of difficulty.

Piece A is to be learned by reading it right through repeatedly. When the subject thinks that he almost knows the piece, he should note exactly how long he has taken, and then he should write out as much as he can remember of the poem.

After a rest the same time should be devoted to Piece B, but Piece B should be learned by sections, the first section, separated from the rest by a vertical line, being repeated until the subject thinks he knows it. Then he should proceed to the second part and learn that thoroughly, and so on until the allotted time is up. Then he should write down as much as possible of the poem.

The amounts learned by the respective methods may now be compared by reckoning the number of words known.

If there is any slackening of effort due to fatigue during the learning of the second piece it should be noted that this is to the disadvantage of the method used second. On the other hand, any improvement due to practice will favour the method used second. These complicating factors can be allowed for by means of a supplementary experiment, in which the order of the methods used is reversed, the sectional method now being taken first. For this experiment the selections given at the end of this chapter may be used.

Alternative Methods.—A method sometimes suggested for doing the experiment is as follows. Piece A is to be learned by the sectional method, the student continuing until he knows the piece perfectly, and noting the time taken or the number of repetitions required. Piece B is then to be learned by the whole method until known perfectly, and the time or number of repetitions noted.

An objection to this method lies in the possibility of wasting more time with one piece than the other by testing oneself to see if one knows it, and it would obviously be awkward to try to measure the time wasted. For this reason I have modified the method as above. But the difficulty may perhaps be avoided if the subject takes care to let each testing be also an occasion for learning. The method has the advantage of securing that the poems shall be completely learned, and this is likely to show more clearly the superiority of the whole method, for the last few minutes tell very heavily with the whole method.

In a *class experiment* the following method may prove more convenient. Let half the class take Piece A and learn it by the sectional method, the other half meanwhile learning Piece B also by the sectional method. Lines are inserted here and there in Piece A to mark the suggested sections for this experiment. Let the class continue learning until one member declares that he knows the piece. Note the exact time allowed. Then let them write out as much of the pieces as they can remember.

After a rest interval of ten minutes the first half of the class should learn Piece B by the entire method, the rest of the class learning Piece A by the entire method, for the same length of time as allowed previously. As before, they must now write out all they can remember, and the total score of all the class by the sectional method should be compared with the total score by the entire method. As each piece has been learned by each method, the possibility of an erroneous conclusion due to the greater difficulty of one piece is avoided.

If time allows, however, each member of the class should follow one of the methods previously described, as the "class experiment" method cuts short the time required by slow learners, to the detriment of the whole method.

Piece A.[1]

Oh! yet a few short years of useful life,
And all will be complete, thy race be run,
Thy monument of glory will be raised; |
Then, though (too weak to treat the ways of truth)
This age fall back to old idolatry, |
Though men return to servitude as fast
As the tide ebbs, to ignominy and shame,
By nations, sink together, we shall still
Find solace—knowing what we have learnt to know, |
Rich in true happiness if allowed to be
Faithful alike in forwarding a day
Of firmer trust, | joint labourers in the work
(Should Providence such grace to us vouchsafe)
Of their deliverance, surely yet to come. |
Prophets of Nature, we to them will speak
A lasting inspiration, sanctified
By reason, blest by faith: | what we have loved,
Others will love, and we will teach them how; |
Instruct them how the mind of man becomes
A thousand times more beautiful than the earth
On which he dwells, | above this frame of things
(Which, 'mid all revolution in the hopes
And fears of men, doth still remain unchanged) |
In beauty exalted, as it is itself
Of quality and fabric more divine.

[1] The selections are from Wordsworth's *Prelude*. Should either passage be known, or should the student desire shorter or easier pieces, it would be well to use instead the selections from Mrs. Browning's *Aurora Leigh* given at the end of this chapter. Students take, on the average, from twenty minutes to half an hour to learn one of the selections from Wordsworth.

PIECE B.

This spiritual Love acts not nor can exist
Without Imagination, which, in truth,
Is but another name for absolute power |
And clearest insight, amplitude of mind,
And Reason in her most exalted mood. |
This faculty hath been the feeding source
Of our long labour: we have traced the stream
From the blind cavern whence is faintly heard
Its natal murmur: | followed it to light
And open day: accompanied its course
Among the ways of Nature, for a time
Lost sight of it bewildered and engulphed: |
Then given it greeting as it rose once more
In strength, reflecting from its placid breast
The works of man and face of human life; |
And lastly from its progress have we drawn
Faith in life endless, the sustaining thought
Of human Being, Eternity, and God. |
Imagination having been our theme,
So also hath that intellectual Love, |
For they are each in each, and cannot stand
Dividually.—Here must thou be, O Man!
Power to thyself; no Helper hast thou here; |
Here keepest thou in singleness thy state:
No other can divide with thee this work. |

For a combined discussion of the results of this experiment and of Experiment X. see p. 109.

Experiment X.

The Learning of Vocabularies.—The test is to learn the following lists of German words, A and B, by two different methods. Students who know German should use the lists of Spanish words given on pp. 24, 25; or these latter may be used for a supplementary experiment.

Learn List A by repeating the first word and its meaning five times, then proceed to the second word and repeat that and its meaning five times, and so on. Note the time taken by this procedure. If you have a metronome, or a loud ticking clock, it would be well to set it going and move the attention from word to meaning, or vice versa, once every second. When you have thus completed the list, write down the meanings of the words written below the list. In the case of the English words give the corresponding German words.

List A.

Aufmerksamkeit	Attention
Bewegung	Movement
Empfindung	Sensation
Bewusstsein	Consciousness
Gebröckel	Gratings
Reiz	Stimulus
Entwicklung	Development
Gemeinschaft	Community
Anschaulich	Perceptual
Entscheidung	Resolution
Kerbe	Notch
Prahler	Boaster
Höken	Higgle
Flicken	Patch
Bedrohen	Threaten
Schuppig	Scaly

Test on List A.

Give the English or German for the following words :—

Kerbe	*Reiz*	Patch	*Anschaulich*
Bewusstsein	*Beweguug*	Threaten	Attention
Sensation	*Gemeinschaft*	*Prahler*	Scaly
Resolution	*Entwicklung*	*Gebröckel*	*Höken*

After a short period of rest learn List B by reading the whole list through from beginning to end five times. Try to go at the same pace that you did with List A, if possible using a metronome or clock as before. Note the time taken. It would be better still if you can get a partner to tell you when you have taken as long over List B as you did over List A.

After reading the list through five times write down the meanings of the words given in the Test on List B.

List B.

Auffassung	Perception
Bedingung	Condition
Speicher	Granary
Einschärfung	Injunction
Erinnerung	Memory
Vorstellung	Idea
Zweckmässig	Purposive
Hemmung	Inhibition
Begriff	Concept
Aehnlichkeit	Similarity
Erfahrung	Experience
Kegel	Ninepin
Pflüger	Ploughman
Hutung	Pasture
Fresser	Glutton
Befugt	Authorised

TEST ON LIST B.

Hemmung	*Aehnlichkeit*	Perception	*Begriff*
Bedingung	Experience	*Zweckmässig*	*Einschärfung*
Ploughman	Pasture	*Fresser*	*Befugt*
Idea	Ninepin	*Speicher*	*Erinnerung*

Compare the number of words right in the two tests.

If the time taken in List B was not exactly the same as that for List A proportionate allowance must be made for the difference in comparing the scores.

Supplementary Experiment.—It would be well for the private student to do a supplementary experiment with the lists of Spanish words, reversing the previous order of the methods (*i.e.* taking the "whole" method first) and adding the results of the two experiments together. Thus he will counteract the advantage gained by the method used second, in the German test, through any acquired facility at pronouncing the words. In a class experiment this can be allowed for by half the class using the whole method for the first list and the other half using the sectional method.

SPANISH WORDS.

LIST A.

Entregar	Transfer
Alcanzar	Follow
Fuero	Law
Garrama	Robbery
Aldea	Hamlet
Pozuelo	Well
Embaucar	Deceive
Careta	Mask
Farandula	Comedian
Casado	Married

Test on List A.

Give the English or Spanish meanings of the following words: hamlet, *casado*, *farandula*, *alcanzar*, robbery, *fuero*, deceive, mask, *entregar*, well.

List B.

Camama	Humbug
Fulano	So and so
Poyata	Cupboard
Cachones	Breakers
Delgado	Thin
Garruchuela	Pulley
Dichoso	Fortunate
Embotar	Blunt
Golondro	Desire
Estambre	Worsted

Test on List B.

Give the English or Spanish meanings of the following words: *cachones*, humbug, *poyata*, desire, *delgado*, worsted, *garruchuela*, *dichoso*, so and so, blunt.

Alternative Selections.

Piece A.

He never could be anything complete,
Except a loyal, upright gentleman, |
A liberal landlord, graceful diner-out,
And entertainer more than hospitable,
Whom authors dine with and forget the hock. |
Whatever he believes, and it is much,
But nowise certain, now here and now there,

He still has sympathies beyond his creed
Diverting him from action. | In the House,
No party counts upon him, while for all
His speeches have a noticeable weight. |
Men like his books too (he has written books),
Which, safe to lie beside a bishop's chair,
At times outreach themselves with jets of fire |
At which the foremost of the progressists
May warm audacious hands in passing by.

PIECE B.

I wandered up and down the terraced streets,
The glittering boulevards, the white colonnades,
Of fair fantastic Paris | who wears trees
Like plumes, as if man made them, spire and tower
As if they had grown by nature, | tossing up
Her fountains in the sunshine of the squares,
As if in beauty's game she tossed the dice, |
Or blew the silver down-balls of her dreams
To sow futurity with seeds of thought
And count the passage of her festive hours. |
The city swims in verdure, beautiful
As Venice on the waters, the sea-swan. |
What bosky gardens dropped in close-walled courts
Like plums in ladies' laps who start and laugh : |
What miles of streets that run on after trees,
Still carrying all the necessary shops.

For a discussion of the results of this experiment see p. 109.

CHAPTER V.

MENTAL TYPES REVEALED BY ASSOCIATIONS AND DESCRIPTIONS.

Experiment XI.

Do this and the two following experiments before reading the discussion of them in Part II., Chapter V.

(*a*) Write out a list of words, in the order in which they occur to you, beginning with any word you choose. Do not hesitate to write down whatever comes into your mind, however disconnected it may seem to be from the previous words. When you have completed the list go over it again and add a note to each word, if possible, to make it clear exactly what you had in mind when the word occurred to you.

(*b*) After doing the next experiment (XII.) write out another list of words as above.

(*c*) After doing Experiment XIII. write out a third list of words as above.

It would be better still if these lists could be written on different days and if one or two more could be done, starting with any word the subject chooses.

Experiment XII.

Complete the following partial sentences :—

1. I am now . . . .
2. He saw clearly . . . .
3. In this town . . .
4. It is raining and . . . .
5. Yesterday we were . . . .
6. Very few men . . . .
7. Outside the town . . .

Experiment XIII.

Place an old penny or halfpenny before you and write a dozen or twenty lines about it.

Do the same with a used stamp, or an old pen-nib.

For a discussion of the results of these experiments see p. 114.

CHAPTER VI.

ROTE MEMORY TESTS.

Experiments XIV., XV., and XVI.

The object of these experiments is to discover whether the subject has a better memory for impressions of sight or impressions of sound, and also to find to what extent he uses visual imagery even in remembering sounds, *e.g.* by picturing words which he hears spoken, or, on the other hand, to what extent he uses sound imagery in remembering things seen, *e.g.* by repeating to himself words which he sees.

For these experiments a partner is essential. First perform the following tests upon him, and then get him to do similar tests upon yourself, only substituting different letters, words, etc., for those given below.

Experiment XIVa.

Auditory Memory.—The first test consists in reading aloud to the subject a number of letters; the subject then writes down the letters which he has heard.

For the sake of comparison it is desirable that a regular unit of time should be chosen (say one second), and that a new letter should be read out each second. If the reader possesses a metronome it will be found helpful to set this

ticking one per second; the operator then reads out a new letter at each tick. Failing a metronome an ordinary watch can easily be used. Let the operator hold this to his ear until he apprehends clearly the rhythmic tick of the watch. Probably four ticks make about one second. If he taps his foot every fourth tick he will soon get the rhythm quite definitely. Still keeping the watch at his ear, let him now warn the subject to be ready and then read out the set of letters below, calling out a new letter at every fourth tick.

When all the letters have been read out the subject must write down all that he can remember.[1] The subject should be instructed to remember the letters by their *sounds* and to avoid visualising as far as possible.

C N P F S G B W D L Q T

This is primarily a test of auditory memory. The student, however, should note whether he visualised any of the letters. In so far as this is done the test is not a purely auditory test.

The total score should be noted, no marks being lost because of incorrect order.

A similar further test should now be done, the operator becoming the subject and the previous subject becoming the operator and preparing a new list of twelve letters. Care must be taken, in forming a new list of letters, that no associations are suggested by the grouping of the letters. For example L.S.D. or I.L.P. would be bad sequences. Vowels should not be used, as one may chance to form a complete word with two adjoining letters. Any help gained from such associations should be noted.

[1] To make the subject duly cautious he should be informed that the writing down of a letter which was not given will score *minus* one.

Experiment XIVb.

Visual Memory.—A similar test for visual memory can now be carried out. As before, warn your subject to be ready and then expose the following group of letters for the same length of time as was taken to read out the twelve letters used in test A.

The subject must be instructed previously to keep his eye upon the centre letter, but at the same time he must try to remember the other letters and also their exact positions in the group.

When the time is up the subject must write down the letters, arranging them exactly as they are arranged in the given group. Letters put in their right places should score two marks; correct letters, but in their wrong places, one mark.

The subject must be instructed to avoid *saying* the letters to himself when looking at them.

R
L V
K M T
X D
J

Now again the subject should become the operator and prepare a similar group to test his partner.

This test is primarily a test of visual memory. But some will find it difficult to avoid saying the letters to themselves when looking at the group. In so far as this is done the test fails to be a purely visual test. But those who have a good visual memory will have a great advantage in remembering the exact arrangement of the letters.

As always in these memory experiments the subject should note whether he derives any assistance from associations, *e.g.* of words with the letters.

Experiment XVa.

Second Test of Auditory Memory.—Inform your partner that you are going to read out to him nine nonsense syllables of three letters each, specially constructed for this kind of test.

Read them out at the same pace as you read the letters, using the metronome or watch as before.

The list should be read three times; then the subject must write out all the syllables he can remember, spelling them as they sounded, and not troubling about position. As always, give your subject the warning "Ready" three or four seconds before you start. The nonsense syllables must be pronounced very distinctly.

MEB PIV RON WOF GAN TOD HIX DIB WAP

As before, the operator should now become the subject, his partner preparing a list of nine nonsense syllables. Great care must be taken to avoid resemblance in a nonsense syllable to any word or part of a word, but it is exceedingly difficult to secure an entire absence of such suggestions in a long list of nonsense syllables. Sometimes a nonsense syllable looks all right but suggests a word as soon as it is read aloud. Any such suggestions in the course of the experiment should be noted.

Experiment XVb.

Second Visual Memory Test.—Expose the following group of nonsense syllables before your subject, using the watch or metronome as before, and pointing to a new syllable every second. The subject must try not to say the syllables to himself.

After going over the syllables twice thus from top to

bottom, the subject must go over them a third time, this time in the opposite direction, from bottom to top. This will make it much more difficult to remember the position of the syllables by the succession of sounds got by pronouncing them silently.

After the third reading the subject must write down the syllables from memory, arranging them in a group as given. One mark is given for every syllable correctly spelled, and an extra mark if it is also in the right position.

SOR
WIB DAK
ZER YIK PO
GEB ZID
VUS

As before, the operator should now become the subject, his partner preparing a new group of nonsense syllables.

Experiment XVIa.

Third Auditory Test.—Read out the following pairs of vowel sounds to the subject. Read out a pair every two seconds, and repeat the whole list three times.

Emphasise the first of the two syllables thus ó–ĭ and let there be a short pause after each pair.

After reading out the list three times, give the test as follows. Read out the first sound of one pair, and ask your subject to write down the pair of which it formed the first.

Here we are testing the power of associating two meaningless sounds together. The subject must try to avoid visualising. This experiment is specially devised to lessen the value of visualisation. For the vowel sounds may mostly be spelt in several different ways and this may lead to confusion if the subject tries to visualise them.

The operator should first read over the list to himself and decide exactly how he is going to pronounce each sound

A sample word showing the suggested pronunciation is printed below each vowel or diphthong.

When writing out the answers to the tests the subject should be told to spell them as they sounded to him, giving a sample word with each vowel or diphthong.

1.	Ó I		5.	OÚ . . . . E	
	(go)	(pit)		(thou)	(get)
2.	AẂ . . . . OO		6.	Í . . . . AY	
	(law)	(pool)		(pit)	(pay)
3.	EÍ . . . . AY		7.	Ó . . . . OU	
	(my)	(pay)		(pot)	(thou)
4.	AḢ . . . . EE		8.	EÉ . . . . OO	
	(ah)	(feel)		(feel)	(pool)

In testing do not follow the order given above.

A rearrangement of similar vowel sounds will now serve as material for the testing of the previous operator.[1]

Experiment XVI b.

Third Visual Test.—The third visual memory test is almost a purely visual test, with meaningless diagrams.

Expose the seven diagrams given below, giving time for the subject to go over all the figures three times.

The operator should use a stop watch as before and point to a new figure every three seconds.

The subject should be informed that the figures consist of three lines, mostly just one inch long, but some only half an inch. Also that all the angles are either 90°, 45°, or the supplement of 45°.

[1] If comparison of results of the partners is desired a third person should act as operator in this experiment; otherwise the partner is likely to fix certain associations in reading out the pairs which he will have to *unlearn*.

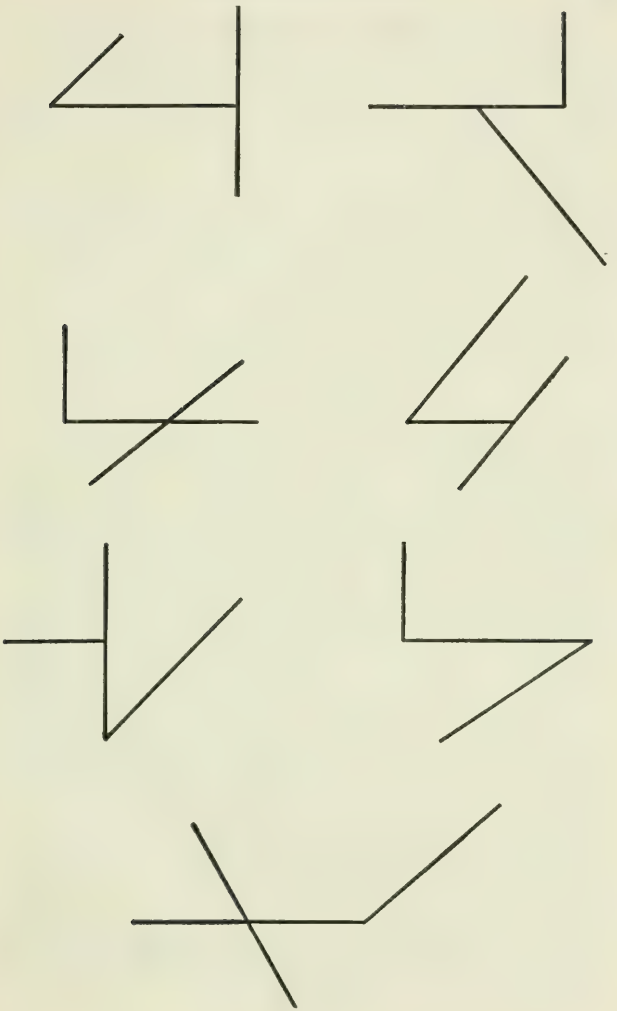


Fig. 1.

After the exposure the subject must reproduce as many figures as possible. A figure must be reproduced with complete accuracy to score a mark. If the subject unintentionally gets associations with any of the figures he should note the fact.

The student should now write down any observations he has made as to his own method of learning and memorising, and especially as to whether he finds much greater facility in remembering visual or auditory impressions. Of course we cannot compare the total of the three visual tests with the total of the three auditory tests, as we have no ground for saying that it is equally easy for the average person to score as well in one set as in the other.[1] But the student may find interesting differences between himself and his partner, the one being superior in auditory and the other in visual memory.

If the experiment is done in class an order of merit, based on all three tests in visual memory, should be drawn up, and then an order in auditory memory. The student will then know his comparative proficiency in each type, and any considerable difference in order will be instructive.

It should be noted that all these tests have been tests of "*Immediate*" memory, *i.e.* of impressions received only a few moments before recall. The student may also try how much of the given material he can recall a day or a week after the tests. If a number do this it will probably be found that those who are best in immediate memory tests are not necessarily best in prolonged memory tests.

For a discussion of the results of Experiments XIV., XV., and XVI. see p. 125.

[1] The writer has sometimes modified the tests he uses in class in order to suit better the private student. Thus he cannot give the usual results.

CHAPTER VII.

ON THE VALUE OF A MAP.

Experiment XVII.

For this experiment the private student needs the assistance of a friend who will act as experimenter while he is the subject. Below are given two pieces of imaginary "history." Piece A is to be read out by the experimenter to the subject (or to a class).

Piece A is illustrated by a map, to which the operator must point at the appropriate times while this piece is being read out. The exact time taken by the lesson should be noted by the experimenter.

The piece should be read only once, then the subject (or class) should write down the answers to the questions given below, which should be read out by the experimenter.

Subsequently Piece B should be read out, at as nearly the same rate as possible to that of Piece A. If it is found that it is finished in less time than was taken to read Piece A (as is not unlikely owing to the use of the map with Piece A) a portion can be re-read until the time is completed. Now Questions B must be answered.

Historical Piece A.

In the first year of the reign of William X., of Zamboo, A.D. 2100, a revolt occurred among his subjects living among the hills of Ranah. In these almost inaccessible heights the king's civilised troops at first could do little to suppress the revolt.

Eventually, however, the greatest leader of the day, General Wodam, took command of the army, and set out with a large force northwards from Kali on the River Tam. This river flows near the base of the highest hills in the Ranah range, and its valley formed an excellent route for the march.

At Sulby, quite by the hills, they were surprised to find a large band of the rebels holding the pass up to the mountain villages. General Wodam, however, leaving a force of 500 men to hold the enemy in check at Sulby, secretly accomplished a forced march towards the south-west and round the hills, and thus captured Otonga, the principal village of the rebels.

[The names of the King and the General are also printed on the map. This is to be regarded as equivalent to their being written on the board in a school lesson.]

Questions on Piece A.

1. In whose reign did the rebellion take place?
2. What was the place of the rebellion?
3. What was the date?
4. Where did the king reign?
5. Who took the lead of the expedition?
6. From what town did they start?
7. Where exactly was the town situated?
8. In which direction did he start?

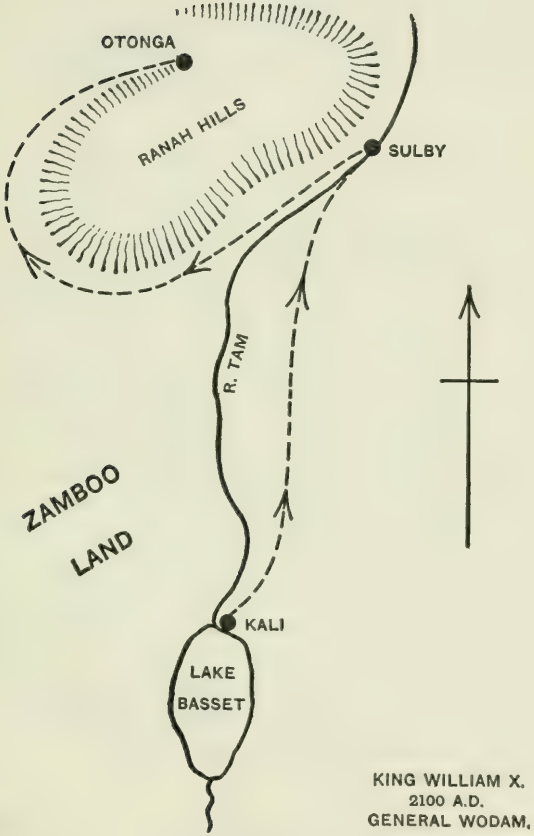

OTONGA
RANAH HILLS
SULBY
R. TAM
ZAMBOO
LAND
KALI
LAKE
BASSET
KING WILLIAM X.
2100 A.D.
GENERAL WODAM.

Fig. 2.

9. How was the route determined?
10. Where did they find the first rebels?
11. How many men did they leave there?
12. In which direction did the general now march?
13. What was the name of the place captured?

Historical Piece B.

The discovery of Feddah Land was the occasion of many interesting adventures. Captain Betler, who was in command of the ship, approached the land from the east, following the strong currents which set in that direction. Starting in the reign of Peter VI., A.D. 1560, from Kenda Town on the Island of Fanly, they sailed for some days in dangerous seas, and eventually reached the mainland of Feddah with some difficulty. The place at first seemed almost uninhabitable, little being discovered in the way of food. Eventually the party of discovery established their base at a spot they named Erman, situated between two huge promontories. Hence they started into the interior, taking with them rations for thirty days which they had brought from the ship. They had not gone many days directly inland when Captain Betler found that a sharp turn towards the north was necessary, to avoid the huge volcano (called by them Aurora, after the ship). Nestling under the lee of this mighty mountain they discovered a charming glen where they made their second depôt, named Densar.

Questions on Piece B.

1. What was the name of the land?
2. Who was the captain?
3. From what direction did they approach the land?

4. How was this direction determined?
5. What was the name of the king?
6. What was the date of the discovery?
7. From what town did they start?
8. Where was this town situated?
9. What was their first base?
10. Where was it situated?
11. For how long had they rations?
12. In what direction had they to turn after going inland?
13. What was the name of the second depôt?

See p. 128 for a discussion of the results of this experiment.

CHAPTER VIII.

SUBSTANCE, RATIONAL OR LOGICAL MEMORY.

Experiment XVIII.

Read out to your partner (or to yourself) the first list of words below, and ask him to write them down at once. Then read out the second list and ask him to write down these also.

As before make use of your watch or metronome, giving one second to each word.

1. Strict, cot, pan, gate, friend, table, paper, bird, flower, bite, walk, piano, ship, glass, photo, bucket.

2. Christmas, plum-pudding, mistletoe, parties, dancing, games, children, snowball, ice, skating, hole, danger, ducking, cold, bed, doctor.

Note the ease with which the words connected in meaning are recalled and the comparative difficulty of recalling the disconnected words, in spite of the fact that these are considerably shorter. Your partner should now be asked to make similar lists and read them out to you.

Experiment XIX.

For this experiment you need, for the sake of comparison, at least one fellow-subject, who has also been a subject in the rote memory tests.

Get your partner to read over with you the three following passages, the first two of which are taken from a

daily newspaper. After all three have been read, close the book, and attempt both of you to reproduce all that you can remember, not seeking to reproduce the exact words, but making sure at least of as many ideas as possible. This experiment is of special interest if done by a group of persons who have already done the rote memory tests. The point of the experiment lies in the comparison of the results with those of the rote memory tests: one fellow-subject may prove quite inadequate for the purpose of comparison.

(i) *Flooding the Sahara and its effects.*

The project of flooding the Sahara desert and converting it into a great inland sea has again been mooted, this time by a distinguished French engineer, but the scheme, as it always does, has thrown the scientific world into a paroxysm of fear. The hot sands of the Sahara, though they are so many hundred thousand miles of waste, play the part of what has been called the stove of Europe. Let in the flood of cooling waters, and, according to a distinguished professor, the climate of France and Germany will become sub-Arctic, while England will be almost uninhabitable.

(ii) *Causes of the present labour troubles.*

In the consideration of the present labour troubles there is a tendency to overlook the important part which the natural desire of mankind to be better off plays in provoking discontent. A recent writer thinks that existing social conditions are not the sole cause of the unrest through which we are now passing.

It arises in very many instances from the higher conceptions of life which have been formed by the workers. Education has awakened aspirations which, in the present circumstances, it is impossible to realise. Men and women

are asking for better wages and working conditions simply because they desire to live better, cleaner and healthier lives, the benefits of which they have been taught to appreciate.

(iii) *The Influence of the Press.*

As the influence of the hearth depends from day to day upon the way in which the parents naturally accentuate some things in word and deed and let others pass away unnoted amongst their ever-watchful children: so is the influence of the daily press upon the national mind. They might fill their pages from day to day with the records of crime, and feed their readers on the refuse of the police courts. They might ignore good causes and great ideas of reform, advocating none of them and expounding none of them when they are weak, but leaving them to gather force as best they may. Instead of guiding they might follow the interests of men, and, in following, not always follow the best of them. And if they did this, day by day, I do not think it would be easy to measure the consequences on the national character. But, taking the daily press of this country as a whole, it seems to me that they do much better. They deliberately exclude what they know their subscribers would read; there are appetites which they will not feed and tastes which they will not pamper.—From *Social Powers*, by Sir Henry Jones.

The marking of the reproductions of these passages is difficult. A mark should be awarded for all the broad facts given, even if they are differently expressed and even if minor points are omitted or are inaccurate. Below is given a suggested analysis and system of marking for passage (i). The subject can agree with his partner for similar marking for the remaining pieces.

One mark for the idea that	}	the flooding of the Sahara will convert it into *an inland sea or lake.*
,,	,,	it has been suggested by *an engineer.*
,,	,,	it has been suggested *again,* or any words that imply that the suggestion had been made before.
,,	,,	the suggestion has *caused fear.*
,,	,,	the fear has been caused *in the scientific world* (because it is the scientific world that can understand the consequences).
,,	,,	this is *what always happens.*
,,	,,	the Sahara *acts as a stove.*
,,	,,	it warms *Europe.*
,,	,,	the Sahara *appears to be waste land.*
,,	,,	the *waters will have a cooling effect.*
,,	,,	they will make *France and Germany* (or N.W. Europe) *sub-Arctic* (or excessively cold).
,,	,,	they will make *England almost uninhabitable.*

The other pieces should now be marked in a similar manner.

See p. 130 for a discussion of the results of this experiment.

CHAPTER IX.

THE IMPROVEMENT OF THE MEMORY AND THE TRANSFER OF MEMORY IMPROVEMENT.

Experiment XX.

Purpose of the Experiment.—Can the memory be improved by practice? Supposing that by practising the learning of poetry I can improve my memory for poetry, does this also improve my memory for prose, or for dates, or for mathematical formulae, or lists of foreign words? These are the questions which we now proceed to put to the test. It is possible for a single student (or a pair of students) to perform the experiment and to gain clearer insight into the relevant facts for himself by doing so. But for statistical results of any value we need the co-operation of a class. We will describe the experiment first as a class experiment and then indicate what may be done by the student working alone.

Method of the Experiment.—The principle and method of the experiment are broadly as follows. We will suppose that the class numbers twenty-four. The whole class first undergoes the memory Tests A in syllables, letters, and verse, and their scores are noted. The class is now divided into three groups of eight each. During the following fortnight (or week) Group I. learn poetry by heart for half-an-hour a day (or an hour a day for a week); Group II

learn vocabularies of any foreign language for half-an-hour a day; while Group III., called the "control" group, do nothing specially for the experiment, only avoiding as far as possible any learning of verse or vocabulary during that time. At the end of the fortnight the whole class undergoes the memory Tests B in letters, nonsense syllables, and verse, which have been made as much like Tests A in degree of difficulty as possible.

By a comparison of the results of Test B with those of Test A it will now appear what improvement has taken place in the capacity to memorise the various kinds of material.

The control group serves three purposes. (1) It is a check upon the comparative difficulty of the two tests A and B. If one is much more difficult than the other it will appear in the different records of the control group's scores in the respective tests.

(2) It indicates the extent of any possible improvement of memorising due to natural growth, or to the ordinary learning work done during the fortnight.

(3) Thirdly, and perhaps most important, it indicates the effect of practice gained merely in the doing of Test A itself. This of itself will aid subjects somewhat when they come to Test B, more especially as regards the test with unfamiliar nonsense syllables.

Thus if the control group shows a certain improvement in Test B upon Test A we must allow for this in considering how much of the improvement of Groups I. and II. is due to their special practice with poetry or vocabularies in the course in the last fortnight. Thus an improvement in the second poetry test of 20 per cent. on the part of Group I. cannot be attributed to their fortnight's practice in learning poetry if the control group also shows an improvement of 20 per cent. in the second poetry test.

It is highly desirable that at the start the groups should be fairly equal, on the average, in their capacity to do such tests as A and B. A list should therefore be drawn up of the order of merit on the basis of the results of Test A. The first student on the list should be put in Group I., the second in Group II., the third in Group III., the fourth in Group III., the fifth in Group II., and so on, thus—

Group I.	Group II.	Group III.
1	2	3
6	5	4
7	8	9
12	11	10

Thus each group will have its fair share of subjects with good memories and also of subjects with weak memories for such material as is given in the tests.

Both Tests A and B should be done at about the same time of the day and when the subjects are feeling quite fresh, so as to avoid any variations due to fatigue.

Method for Individual Students.—If a pair of students are working at the experiment one may act as a "control," as above, taking Test A with his partner before the practice period and test B also at the same time as his partner afterwards. This will form a partial, though of course inadequate check, not only upon the equal difficulty of Tests A and B,[1] but also on the amount of improvement in Test B which is likely to result merely from the practice

[1] Of course it does not avoid the possible errors due to one test being for some reason harder for one subject, and the other test being the harder for another subject. By taking groups of subjects, however, one greatly lessens the chances of such errors.

In a class experiment it would be well for half of each group to do Test A first and Test B later, the other half taking Test B first and Test A later.

gained in Test A itself. This is not likely to be much in the case of the poetry, but with the letters and nonsense syllables it may be considerable.

Owing to the possible variations due to individual peculiarities, variations in fatigue, etc., only very marked improvements in the tests on the part of the practised partner can even tentatively be ascribed to the practice during the week in poetry and vocabularies.

Experiments of this nature require a large number of subjects before we can generalise with confidence. Yet the private student may well learn the principle involved in the method of the experiment and also he may learn much from self-observation in the course of the experiment. He should notice carefully any method or device he adopts in the course of the practice period, any way in which he modifies his way of learning so as to make it more efficient. He should make a note of these at the time without waiting to see the result of the experiment.

The student should get his partner to time him while doing the tests. In the class experiments the teacher will of course check the time, unless the students are working in pairs.

Tests A.[1]

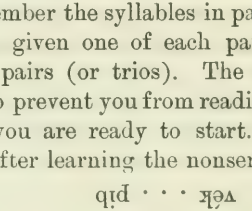
(1) **Learning Letters.**—Look at the group of letters at the top of the following page for ten seconds, keeping your eye on the centre letter, but trying to remember all. Then write down the letters in exactly the same arrangement as that given. Reckon one mark for every letter right, and two if it is in its correct place. Do not turn over until your partner is ready to time you.

[1] As before, in all rote memory tests note whether any associations or suggestions of meaning occur. These must be allowed for in comparing results.

LETTERS FOR TEST I.

F
B L
Z R G
T M
J

(2) **Learning Nonsense Syllables.**—Learn the following groups of nonsense syllables, with the rhythmic emphasis as marked, emphasising the first syllable of the pair or trio. Repeat the groups thus for two minutes, trying to remember the syllables in pairs (or trios), so that when you are given one of each pair (or trio) you can complete the pairs (or trios). The syllables are turned upside down to prevent you from reading them easily before the moment you are ready to start. Do the test below immediately after learning the nonsense syllables.



Write down the syllable or syllables which were grouped with the following syllables. (N.B. It is not necessarily the *first* syllable of the pair which is given here.)

zer, jek, dax, rus, lev, vek, wum, geb

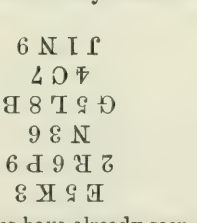
(3) **Learning Poetry.**—Learn the following lines of poetry. For the sake of uniformity use the same method throughout these tests, whatever method you are accustomed to. Note exactly how long you take to learn the lines perfectly.

Hast thou not mark'd, when o'er thy startled head
Sudden and deep the thunder-peal has roll'd,
How, when its echoes fell, a silence dead
Sunk on the wood, the meadow, and the wold?
The rye-grass shakes not on the sod-built fold,
The rustling aspen's leaves are mute and still,
The wall-flower waves not on the ruined hold,
Till, murmuring distant first, then near and shrill,
The savage whirlwind wakes, and sweeps the groaning hill.

(4) **Auditory Memory Test.**—Get your partner to read out to you the groups of letters and figures written below.[1] They are to be read out in a monotonous tone, no emphasis being given to the first or to any letter or figure of the group.

One letter or figure should be read every second, except that at the end of each group there should be a pause of three seconds. A watch should be used as described in Experiment VIII., p. 16.

The whole series should be read out three times and then the subject should write down all that he can remember, in groups as given. One mark should be allowed for each letter or figure in its right group. No marks are to be lost for the wrong position of any letter or figure, if it is in its proper group.



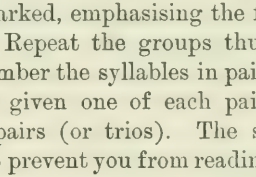
[1] As your partner will thus have already seen this test, you must prepare a test of a similar nature for him if he is to do the experiment subsequently.

Test B.[1]

As before, get a friend to time you in all these tests.

(1) **Learning Letters.**—Look at the group of letters on the top of page 54 for ten seconds, keeping your eye upon the centre letter, but trying to remember all. Then write down the letters in exactly the same arrangement as that given. Reckon one mark for every letter right, and two if it is in its correct place.

(2) **Learning Nonsense Syllables.**—Learn the following groups of nonsense syllables, with the rhythmic emphasis as marked, emphasising the first syllable of each pair or trio. Repeat the groups thus for two minutes, trying to remember the syllables in pairs (or trios), so that when you are given one of each pair (or trio) you can complete the pairs (or trios). The syllables are turned upside down to prevent you from reading them easily before the moment you are ready to start. Do the test below immediately after learning the nonsense syllables.



Write down the syllable or syllables which were grouped with the following syllables. (N.B. It is not necessarily the first syllable of the pair that is given here.)

mef, ber, dov, vim, pib, rux, nud, yot

[1] As before, note whether any associations affect the results of the rote memory tests.

(3) **Learning Poetry.**—Learn the following lines of poetry, using the same method as before. Note exactly how long you take to learn the lines perfectly.

Stranger! if e'er thine ardent step hath traced
The northern realms of ancient Caledon,
Where the proud Queen of Wilderness hath placed
By lake and cataract her lonely throne;
Sublime but sad delight thy soul hath known,
Gazing on pathless glen and mountain high,
Listing where from the cliffs the torrents thrown
Mingle their echoes with the eagle's cry,
And with the sounding lake, and with the moaning sky.

Auditory Memory Tests.—Get your partner to read out to you, in a monotonous tone, the groups of figures and letters written below, no emphasis being laid on any letter or figure of the group.

One letter or figure should be read every second, except that at the end of each group there should be a pause of three seconds. (A watch should be used as described in Experiment VIII., p. 16.)

The whole series should be read over three times and then the subject should write down all that he can remember, in groups as given. One mark should be allowed for each letter or figure in its right group. No marks are to be lost for the wrong position of any letter or figure if it is in its proper group.

M 3 L 5 Q
6 2 K
5 H 8 S
7 Ω Λ 4 P
I X 3
4 B 7 O

For a discussion of the results of this experiment see p. 142.

LETTERS FOR TEST I.

H
N C
D P K
F S
W

CHAPTER X.

THE ACQUIREMENT OF SKILL. MOTOR HABITS AND MOTOR MEMORY. THE METHOD OF TRIAL AND ERROR.

Experiment XXI.

Method of Experiment.—For this experiment a small mirror and some squared paper are required. The squares should be small, preferably not less than ten divisions to the inch.

Trace on the paper twelve figures similar to the one given below. This can easily be done by placing the given figure over a portion of the squared paper, pricking through to the paper at the points of the various angles, and then joining these points on the squared paper with pencilled lines.

Stand the mirror upright on the table about a foot in front of you, and place the first traced copy of the irregular figure on the table between you and the foot of the mirror. Arrange the paper so that you can easily see the reflection of your pattern in the mirror.

The task is to trace over the pattern as rapidly as possible with a pencil, while looking only into the mirror. A screen should be introduced between the eyes of the subject and the pattern itself. A piece of paper held by the subject in the left hand will suffice.

Start with your pencil on the point marked A and move it over the pattern in the direction indicated by the arrow,

until you come back to A again. Note the exact number of seconds it takes to complete the round. Try to trace the lines as accurately as possible and at the same time try to go as fast as possible. Note any introspective observations after you have completed the figure; *e.g.*, do you

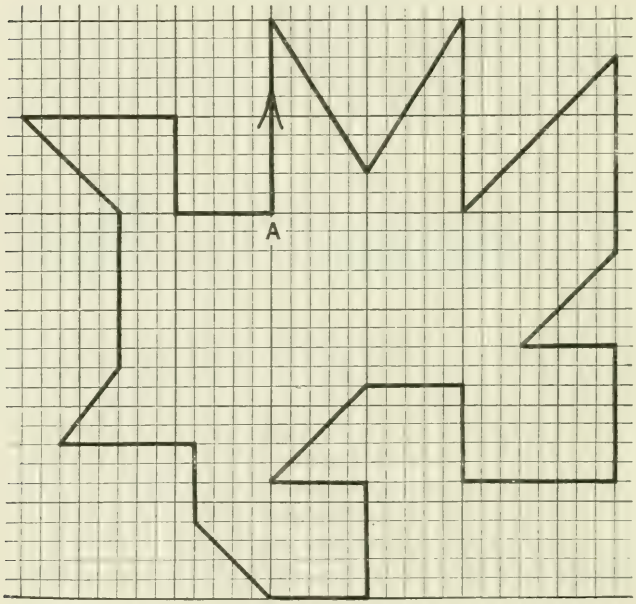


Fig. 3.

make use of reflection as to which way you should move the pencil (this should be avoided as far as possible), or do you just "go at it slap-dash"? How is your progress affected by pleasure at success or annoyance at failure? Does your improvement seem to be constant, or is it irregular?

Now proceed at once with the second figure, again noting the time taken, and so on till the twelve figures are completed.

If the reader subsequently tries to trace the figure directly, *i.e.* without the use of a mirror, he will probably find an amusing disturbance of the normal coordinations of eye and hand.

Treatment of Results.—The student should plot a curve showing the various times taken for the different figures.

The accuracy of the work now remains to be calculated. One error should be counted every time the pencil moves one square away from the line. If it moves two squares away, this counts two errors. Or if it moves only one square away but continues so for two squares, this counts as two errors. Similarly an error should be counted for each individual square in which it continues to be one square away from the line. The total errors in each figure should thus be estimated and a curve of errors plotted.[1]

For a discussion of the results of this experiment see p. 147.

Experiment XXII.

Motor Memory Tests.—As supplementary to the preceding experiment two brief motor tests are described in this and the following experiment.

[1] The method of this experiment is a modified form of that of W. F. Dearborn and D. Starch. The plan of estimating errors simply by reckoning the number of attempts to move back to the pattern line seems to me unsatisfactory.

For another method of experiment with mirror-drawing see C. Burt, "Experimental Tests of General Intelligence," *Brit. Jour. of Psych.*, Vol. III.

In the learning of all movements with the hand, complicated or simple, we are guided, partly at least, by a series of motor sensations due to the position of the fingers, hand, and arm, among which the most important are the sensations derived from the joints. When a movement is thoroughly learned it is because a given complex of motor sensations suggests the next appropriate movement, and the new complex of sensations, due to the new position, suggests the next movement, and so on.

Similar processes are involved in all such actions as writing, drawing, woodwork, etc., though of course the eye also plays a highly important part in such work. The desirability of training directly the motor sensations themselves in teaching children to write has recently been especially emphasised by Mme Montessori, who makes the little beginners move their fingers over large letters made of sandpaper. In this way movement is guided by touch, and not merely by sight.

Some tests of such motor sensitivity and of the ease or difficulty with which the necessary associations are made and previous motor sensations recalled are afforded by Experiments XXII. and XXIII.

Memory of Direction of Movement.—Get your partner to hold a long pencil firmly in his hand in a vertical position, and to close his eyes. Do not let him see Figure 4 on the next page.

You must now also take hold of the pencil near the top, and practise guiding his hand. The subject's arm must be raised from the table so that the hand can be moved easily by the operator.

The operator should now trace the lines of the figure below with the pencil, the subject still holding it, so that he will feel the movements though he will not see them.

Then move the point of the pencil till it is over a clean sheet of paper, and let the subject try to repeat exactly the same movements and so draw a similar figure.

The subject must as far as possible avoid counting the movements or visualising the figure when his hand is being guided over it; he must endeavour to concentrate his attention on the sensations due to the moving fingers, hand, and arm. Some subjects, however, may find it impossible to avoid all visualising.

MOTOR MEMORY TEST.

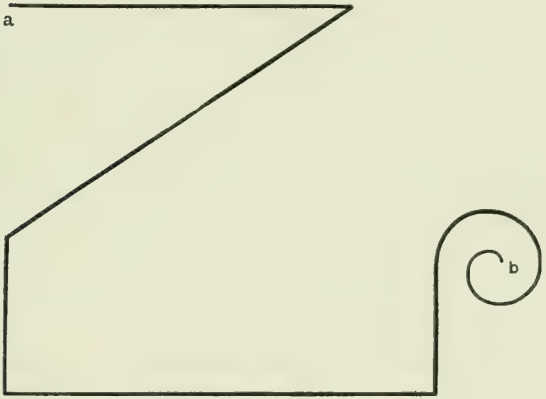


Fig. 4.

If the figure is not done correctly the first time, the subject's hand should be led over it again and again until the figure is done correctly, the number of repetitions necessary being noted.

Several figures (not too small) of equal or greater complexity can easily be devised by the operator. As before, the operator and the subject should now change places.

Experiment XXIII.

Memory of Extent of Movement.—Fasten a tape measure to the edge of a table with drawing-pins. Seat the subject opposite one end, with the tape measure stretching away to his right; he should be near enough to the table to reach two or two-and-a-half feet along the measure with his right hand, without moving his body.

Let him close his eyes, extend his right hand, and rest the first finger on the near end of the tape measure.

The operator should now slide the subject's finger along the tape measure for some distance, say 24 inches, and then slide it back to the end. The hand should be moved at a constant speed, and not so far as to cause any movement of the body.

The subject must now try to slide his finger, without guidance, to exactly the same spot as before.

The operator should note the exact amount of error. Five similar tests with various distances should be done, and the average amount of error noted.

As a variety of this experiment test the memory of "active" movement. Let the subject move his finger along the tape to any distance he desires, with eyes closed; then let him slide his finger back to the end of the tape. Now let him try to move the hand exactly as far as before. Compare the accuracy in this test with that of the test above.

There is no separate discussion of the results of Experiments XXII. and XXIII. They are to be regarded as supplementary to Experiment XXI., which is discussed in Part II., Chapter X., p 147.

CHAPTER XI.

MENTAL FATIGUE.

Experiments XXIV. and XXV.

Purpose of the Experiment.—The object of these experiments is to indicate the manner of the onset of fatigue in the continued performance of mental work, and to show the various conflicting influences, *e.g.* practice, "warming up," boredom, fatigue, which are present at one time or another in the course of prolonged mental work.

The tests which follow may be used also to detect the presence of fatigue at different parts of the day, or to compare the amount of fatigue after working at, say, mathematics with the amount of fatigue after working at history, or after an hour's gymnastics (see Experiment XXV.).

Method of Experiment XXIV.—For such purposes we evidently require a test in which work of a very constant degree of difficulty can be given and which can be accurately and exactly marked. As samples of such tests two are given below, viz. multiplication, and cancellation of letters.

The student should select one of these and it would be well if he could do an hour's, or at least half-an-hour's continuous work at the selected test. Individuals vary greatly, and some may find they get interesting results with less work than this. But the student should go as far as

possible beyond the stage at which he *thinks* he is fatigued. There is no necessity for him to select an hour when he is vigorous and fit for other work. Indeed it is preferable that he should select a period when fatigue is likely to show itself.

He must endeavour to work at full pressure throughout the test. He should secure himself as far as possible from all likelihood of noises or other interruption during the period of work.

If possible he should be timed by a friend who should indicate to him by some signal the end of every two minutes, when the subject should make a mark showing how far he had progressed in his work by that time.

If the student is working alone he should do half a page in Test A (or a couple of columns in Test B) and note the length of time taken. Then he should proceed at once to the next half-page (or columns), timing that, and so on. This method, it should be noticed, introduces a complicating factor not present when the subject is timed by another, —namely, he is aware of the fact that he is improving his pace or otherwise.

Finally, as always, the student is urged to write down at the end of each test any introspective remarks, *e.g.* as to his own feelings of fatigue, the apparent causes of delay at certain points, any change or improvement of method due to practice, and his own impressions as to his comparative speed at different times, the signs of the onset of fatigue, the approach of boredom, the effect of a special effort to press the speed, etc.

Alternative Method for Experiment XXIV.—An interesting variation of either test may be made by introducing a rest of five or ten minutes after the first half-hour's work, and noting the effects, both subjective and

objective, of this interval. The student is recommended to adopt this modified plan. If a class of students is doing the experiment it would be well to divide it into three groups, giving one group no pause in the middle of the work, a second group two minutes' pause and the third group ten minutes' pause.

Of the two following tests the reader is strongly advised to select the second, Test B. The method of the experiment, it is true, is not so simple, but for this very reason it will prove more interesting. Also correction of the results will take less time for Test B than for Test A, and there is less likelihood of muscular and eye fatigue.

For Test B enough material is given for an hour's work. Sample pages of letters suitable for Test A are also given, sufficient to give those readers who select Test B for their "fatigue" experiment some idea also of the nature of the work involved in Test A. Each of these sample pages contains all the letters of the alphabet, each repeated twenty-six times, but in haphazard order. Those who choose Test A for their "fatigue" experiment must select some ordinary printed matter, continuous prose, printed alike throughout, and this should be used throughout the experiment.

Test A.

Cancellation of Letters.

The task in this test is to cross out as quickly as possible every example of several selected letters, in the printed capitals on pages 65 to 67. For example, the subject may decide to cross out every A and every F. The more letters are chosen, of course, the greater the mental effort. Four is a fairly convenient number, say A, F, M, and L.

As all the letters of the alphabet occur an equal number of times within every page, it does not matter much which letters are chosen for deletion.[1]

When ordinary printed prose is used for this test of course it makes a considerable difference which letter is chosen, as some occur so much more frequently than others. The most uncommon letters should then be avoided.

The subject must take care to put his pencil mark right through the letter. A partner should indicate the end of every two minutes, and a mark should be made showing the point reached at that time; if this plan is not adopted the subject must time himself for every half-page. When the beginning of the last period of two minutes is reached the subject should be warned of this fact.

When the period of work is completed the letters crossed out during each period of two minutes should be counted and a graph should be plotted showing the various amounts done in the successive periods. Every occasion on which the subject has omitted to cross out one of the selected letters counts as an error, likewise any letter crossed out which was not one of the selected letters, unless the mistake was apparently a "motor" error (see below). A separate graph should be plotted for errors.

Motor Errors.—Sometimes the student may have evidently intended to cross out one of the selected letters but may not have put his pencil mark properly through the letter. These letters should be included in the score of crossed out letters, but a separate note of them should be made as "motor" errors.

[1] Except that some letters stand out especially clear in a page of printed capitals. For example the student should not select O or Q for cancellation.

WKBROGDJSKWGYARJUIVEUXCETC
OZEJKMDHYUPSYUIVFHJHMDBWSM
PMQTGYLALXRXHPGFCFNQIERCVF
ATOZVNZPNWBLXAZSKQBTIDOLNQ
DMKCIWZHTNEVWOVKYLOHTSPZDA
FLVUMNQSXHRZMFSWIXOKUQPMKO
JLNSVWEIJCXWTYLUORWGDXUJLW
MJNKQETHZIQFXBGHUFRAHGTRUK
TNGIFBRVURGKNBMXPCVDQSVYGP
CPAVFSDGCIBTZASJCQAOYPIACY
BQMEOHWBDJCPTLYZQKLPNBLESU
AHZNAJEGDBZFRXOFJYIEMDRYEX
XWRTOXTZFBKALZIVQMYIPNETXS
EVIFZHWMCEKLZJQBEOIHYUEZVA
BDUAXLVCQFCDIHUSWNZPJOKNAB
JMWNXGCQHTCVDTNJOUWNXICSJA
SMTBGDUFPCBYZFWOIQJMCHUKRP
UNDMRYBTALYBFRMVGDLGFIHUAV
KYDGZSEGWAEOSKSNMLPWSKHQRJ
ORXLPEVDRGLHTFJYOPYQXPQRKG
MVUNLIMGBTJNZJBZYWGESYANKW
HYIXMZTHQMZTWKGLCHVIRPWQYB
APHGRPDWQJTHWPRZUOCLQNXODP
CKDVKMVCOGRELODASKUDARFXCA
IZVQFGELXBQPTRMUFJYIOHYUAN
JEXSFDTCSKBUEXVDOLFSIBNJFS

U K A U R M B X F T A K O I N W K V D W N B N O U I
I W M D J V M Y J K T E Y W N E N S N H D F R Q O V
X L H J K S F J R O W F B D S A Q V O L F S Y N B W
S Y U R D G W X Q H V Y S W U G Q S Y H F G T P N T
M W X M S K E V I O E X F L R U I M W C D A K S R A
W J F E C L P E C Y K L D Q M E P D Q S J M G K A W
Q C N E F C N A X N Q G M G Y E L P D V T X V U O H
H W U F W B N A D S F J M L Q I F D E V M Q J B T M
E Y X V M I G K Y M Y Z O W J C R B F P X D H T R K
A K E L G N Q U C B H T J H I B R T G A V K H P E K
L F M Z K G D C M E K F T H Q O T K C Y X B R W O U
K A Z M Q J B U W Z K S I W U C L Z F L M Y X W G V
Z L X W J V T V Y X A U Z G O S F X R V H W B L X U
V C X H Z N R L D G F Z P M L C W Y N T G U S Q U X
H J W I P M Q K H V O I X R H Z V I D B X T D T Z X
C W E C K T I P I F L B Q K A O J O L B N X Z V C E
U H J X R B F T Z X J D N U Z M F U J D Y U C V P F
U I J R A V D S I Z Q J G R Z N P A I Z T Q D N G A
P S B G I Y N L R I S B Z I S E Y Z A G J D O Z O I
Q I S N F Y Q S J H F P O F E P N T N O I Q T I C A
E Z O H R H L G T P Z Q T P X E Z O G M L Y A Z O P
A P A Q P C G B C W A J D C M R T O L R A O L E C O
G C L Q K Z J W Y R H R D B F R A B V P H G C B P X
R L C B M B E J F A S D Y R L T N S P C S Q V G K O
U E S D U R P Z E G T P K U H N U X M V I Q D Y P U
Y G B P I J H M N V B V Y K Y J T A E H S C H L S O

YRFVYSUTNWILQOMYOGHDEKOYRX
WVLYOCTMAKVOFDHQMIBQUZLXJP
SOKAVUAUMSDACGQESDWUXQFVTK
YKHUQHWTZHYPNCJWHZRKICMHAC
JTXFSZKOEFWYHTQMAEYKVAOJWL
PXRGDGQBHGKVTEUIENUXNAWKID
ZYKTEVUTRNWECFJHVZMNKAPMVO
WJMDVLRFYSQFQAPUMRQSWJWKFE
MXZGJYEJMGDZMSMBDVJAQNMGEV
YJZLICNPSLDZDQTYUYZOFDRZIU
JMXMQWVZMAFKRCAMKRPKNSXPQI
CHTHGHUGUXCBXHFCGKENUVAOHS
NTXJBSXYJYUGCDOQLVRZPSRJQS
ZFXNXVZAYUXZVDCFYAJCGMWXOA
FPLXSIMDTQKZBLIYKGKXIDWKDX
TPWVDFNJCGBPFRBJDCIJRXRNRO
OXPTJWDCIQMLDCLSRJBXOPFSPT
UFBFGWVUAPJBPTBDHSWXAGUBTI
WUARBGZHOHCXTHPBQMDIFRZLGR
NYBDEIHETYLJNECSBOFPKVBCGO
AEBLVNAUTEAOJGNRWRPNSRVHPW
NYEOEBVLWSLZSNEBNFUBPEHZAN
CZEILEIBSJBPTIQICIEOYNCNZC
EUHLCWXWGFIHTHDSQFVAYLGRAU
OWKIIOKOITGSSPGIVYRPELQIDL
QBMULPLZGZRQHKLFOTNTKMLQBM

Experiment XXIV. Test B.

Multiplication.

Columns are given on succeeding pages for multiplication. The method to be pursued may appear somewhat complicated at first, but with a little practice the student will rapidly become accustomed to it. Briefly the method consists in multiplying four successive figures, but paying attention only to unit figures.

Suppose we have the column

6
4
9
2
7
8

The first figure is to be multiplied by the second, viz. $6 \times 4 = 24$. The unit of figure of the result, 4, is now multiplied by the third figure of the column, 9, thus $4 \times 9 = 36$. The unit figure of this result is now multiplied by the fourth figure, viz. $6 \times 2 = 12$. The unit figure of this is now written down beside the 2. Now the student goes back and starts with the second figure of the column, viz. 4, and multiplies it by the third, viz. $4 \times 9 = 36$. As before the unit figure of this result is multiplied by the next figure, thus, $6 \times 2 = 12$, and the unit figure of this is multiplied by the succeeding figure 7, thus, $2 \times 7 = 14$. The unit figure 4 is now written down beside the 7. Now go back again and start with the third figure 9 and multiply it by the underlying figure 2 and proceed as before, writing down the unit of the third result beside the figure 8.

The column will now appear thus,

6
4
9
2..2
7..4
8..8

The subject should proceed in this manner till he reaches the bottom of a column and then he should start afresh with a second column.

One special case must be mentioned. Where the figure which has to be multiplied happens to be 0, 1 must be substituted for it. Thus in the following column

4
5
7
6..2

proceeding as before, $5 \times 4 = 20$. Substituting 1 for 0 and proceeding as before we get $7 \times 1 = 7$, then $7 \times 6 = 42$, the 2 being written down as above. Of course if the 0 appears as the unit figure which has to be written down, it is not changed to 1, but the 0 is written down, as it has not to be further multiplied. It would be well if the student would make a short column and give himself a preliminary practice before starting the experiment proper.

Naturally it is possible to use a much simpler method. For example, we might multiply the first figure by the second and write down the whole result at once, and then multiply the second by the third and write down the whole result and so on, thus

5
8...40
2...16
7. .14

Two important differences, however, would be introduced. In the first place much less mental effort is involved, as the figures are all before one's eyes and there is not the complicating element of retaining one figure only and dropping the other. Secondly, there is much more writing down in proportion to the amount of mental work done, and muscular fatigue of the hand may precede mental fatigue.

A partner should indicate the end of every two minutes to the subject, who must make a mark showing how far he has progressed by that time. When the beginning of the last period is reached the partner should warn the subject of this fact, saying "Last two minutes." Failing a partner, the subject should time himself for each column.

On subsequent pages the requisite columns of figures are given. They will probably be found adequate for an hour's work. On the succeeding pages these columns are reprinted with the correct answers in their right places. These will make possible the rapid correction of the lists, especially if a partner reads out the correct answers.

After correction the student should plot curves indicating the amount of work done in the successive periods of two minutes, and a second curve indicating the number of errors in each period. If the student has been working alone and timing each column he can plot the curve in seconds showing the time taken for the successive columns.

Booklets of twenty pages of similar columns of figures can be obtained from J. Hörning, Universitäts-Buchdruckerei, Heidelberg.

The student may avoid the writing of figures between the printed columns by using a strip of paper for each column. This will enable him to use the printed columns again on a subsequent occasion, or for another subject. It will also greatly facilitate correction. The strips of paper should be prepared and numbered before the experiment is begun.

8	6	8	6	5	6	9	7	8	8
3	3	9	9	1	5	3	8	5	4
5	4	4	2	6	9	8	4	2	3
7	7	5	3	8	8	7	9	6	9
9	2	7	8	3	3	5	4	1	5
4	5	9	5	9	1	3	2	8	7
8	8	3	7	4	7	9	9	4	2
2	1	1	9	7	4	4	8	3	4
6	9	7	5	2	8	7	3	7	1
1	7	2	1	5	6	8	6	5	8
8	9	4	3	8	5	7	7	9	9
9	8	9	6	6	3	9	2	2	3
4	2	8	9	5	3	5	4	5	6
7	6	5	8	4	1	2	7	6	7
6	3	9	9	2	8	3	5	8	2
3	5	6	5	3	5	1	9	3	9
2	8	5	1	6	7	4	8	5	4
5	3	7	7	9	4	7	3	7	8
9	2	4	6	2	1	5	2	5	6
7	9	8	8	5	4	8	6	9	5
3	6	9	9	7	9	6	9	3	2
9	4	2	4	3	6	9	8	8	4
8	5	5	5	8	8	5	4	9	3
5	7	3	7	5	3	8	5	3	6
6	1	2	9	6	4	4	3	5	7
4	9	9	2	1	9	7	8	7	8
7	7	6	3	8	6	5	9	4	9
3	5	5	8	5	7	6	5	2	5
6	2	4	5	7	2	2	4	6	3
9	8	7	2	6	5	5	9	5	5
5	6	8	3	3	8	1	3	4	4
6	7	9	6	2	3	3	2	8	7
5	5	3	9	9	6	8	6	9	6
8	8	8	7	8	2	6	1	6	9

3	2	8	3	9	8	9	8	6	7
8	4	6	4	7	6	7	7	9	8
9	8	3	7	5	1	8	6	4	6
8	6	4	8	3	5	3	2	3	9
1	5	9	6	8	3	2	9	6	3
5	3	5	3	6	8	4	8	8	1
2	9	8	4	2	5	2	3	3	5
4	8	7	7	9	6	6	5	4	7
7	4	2	9	4	2	8	7	9	8
9	1	3	3	3	7	1	1	2	4
2	6	1	5	5	4	3	4	6	2
1	8	8	2	7	3	2	7	7	6
3	3	9	8	5	9	7	5	5	7
6	2	5	1	9	8	9	3	6	9
8	4	6	5	8	6	7	2	9	6
7	8	7	4	1	2	6	9	5	3
2	3	3	3	7	9	2	8	7	5
5	9	6	6	4	7	5	9	6	4
9	7	8	7	2	9	8	6	3	2
3	6	7	9	6	6	7	8	8	3
8	2	6	2	5	1	4	1	9	7
7	9	9	1	8	3	3	4	2	8
6	4	4	8	6	5	2	5	5	9
2	5	9	3	9	8	5	2	4	7
4	7	8	6	4	7	9	9	5	6
9	8	6	1	2	9	8	7	8	5
3	3	7	8	7	2	7	1	9	4
5	4	2	7	5	4	6	3	6	8
7	9	5	9	3	8	1	8	3	3
3	6	3	3	9	6	8	7	4	2
8	2	9	8	7	7	3	9	7	4
4	4	3	5	1	9	5	3	9	2
9	9	6	3	6	3	3	2	8	6
6	6	8	1	3	2	5	6	5	8

5	3	2	3	5	9	1	4	1	9
7	1	4	9	1	6	7	3	3	6
2	7	7	2	3	1	6	6	9	8
9	6	9	7	6	3	4	8	2	3
6	8	5	4	7	9	2	1	7	5
7	6	7	7	4	7	9	4	6	4
8	8	6	9	9	4	5	2	5	7
3	9	3	3	2	3	7	3	8	2
2	3	8	6	6	8	8	2	7	9
4	1	6	2	8	9	7	9	9	5
6	7	1	5	1	6	4	8	4	3
8	2	4	8	3	5	2	7	3	8
1	6	2	4	4	4	9	9	1	4
5	9	3	2	7	3	8	7	6	9
7	5	9	6	5	8	3	8	5	3
9	2	6	9	8	5	9	6	2	5
2	4	5	3	3	4	6	8	9	2
5	3	8	5	6	9	5	3	2	7
8	8	7	2	9	7	2	2	5	8
9	6	2	8	6	6	8	5	8	5
3	9	4	7	3	2	3	3	4	6
2	5	3	4	4	7	9	4	3	9
7	8	8	8	7	8	5	6	8	7
6	2	9	5	2	3	6	1	6	8
1	5	7	9	6	5	7	9	7	1
4	7	8	6	8	2	4	6	8	3
3	9	5	3	5	7	2	5	9	9
6	3	7	1	4	8	6	4	6	7
8	7	6	9	7	3	7	3	7	2
3	2	3	6	1	6	4	6	5	4
6	1	2	7	9	5	3	1	3	5
9	8	6	5	5	4	5	4	4	3
4	6	8	3	8	9	7	2	8	9
7	8	9	2	4	4	9	9	9	8

8	6	8	6	5	6	9	7	8	8
3	3	9	9	1	5	3	8	5	4
5	4	4	2	6	9	8	4	2	3
77	74	50	34	88	82	72	96	62	94
95	28	77	82	34	33	50	42	16	50
40	50	92	50	96	16	33	28	86	75
86	88	35	77	44	78	95	98	42	20
26	18	19	93	76	44	40	86	36	44
64	99	79	55	24	84	76	32	72	16
16	74	22	15	50	64	86	66	50	84
86	97	46	35	88	50	78	78	95	98
92	86	94	60	68	33	98	22	20	36
48	28	86	92	50	39	50	46	55	66
76	64	50	86	44	15	20	72	66	74
62	38	99	98	28	82	33	50	88	22
34	50	64	50	36	50	13	99	34	96
22	88	55	11	64	77	44	80	50	44
50	33	77	75	94	48	74	33	77	86
99	26	48	60	24	11	50	22	55	68
73	92	88	86	50	42	88	68	95	50
35	64	96	94	77	94	66	94	35	22
91	42	26	48	31	66	94	84	80	48
82	50	50	50	80	88	50	48	94	32
50	77	33	77	50	36	88	50	38	64
66	17	26	93	66	46	44	33	50	74
44	95	99	20	16	94	78	84	75	88
78	71	64	38	88	68	50	99	40	94
34	55	50	82	50	72	66	50	22	50
64	20	44	50	77	26	22	44	66	33
94	88	78	22	62	50	50	99	50	55
50	68	86	36	33	88	11	37	44	40
66	72	96	68	22	34	33	26	82	77
55	50	32	94	94	68	80	64	92	62
80	88	88	74	82	28	64	16	68	92

3	2	8	3	9	8	9	8	6	7
8	4	6	4	7	6	7	7	9	8
9	8	3	7	5	1	8	6	4	6
88	64	46	82	35	50	32	22	38	94
16	50	98	64	80	33	26	96	68	36
50	33	50	38	66	80	42	84	86	12
22	97	88	46	28	55	28	32	32	55
44	80	77	74	94	66	66	50	46	75
78	44	24	96	42	22	84	77	94	80
94	18	36	36	36	74	16	15	26	44
24	62	12	55	50	46	34	40	62	28
16	82	88	20	77	38	28	76	76	64
34	34	96	88	55	96	72	50	50	76
66	28	50	18	95	84	98	33	66	96
84	42	66	50	80	66	72	20	99	68
78	82	77	44	11	24	66	99	55	34
22	32	31	33	74	94	26	82	77	50
50	94	66	68	44	76	50	96	60	44
99	72	88	74	26	94	88	68	33	22
37	64	78	94	66	62	76	86	88	36
80	26	66	26	50	18	48	12	96	78
72	96	94	16	88	32	32	42	22	86
68	42	42	84	68	50	28	50	50	92
22	50	94	38	94	80	50	22	44	78
46	77	82	64	48	77	99	98	50	64
92	86	68	14	22	93	82	73	80	50
36	33	74	84	74	28	77	16	92	44
50	42	22	76	50	44	64	39	64	82
75	94	50	94	33	86	16	88	36	34
35	68	33	32	95	64	86	78	48	22
80	22	97	82	75	74	34	92	74	42
42	42	35	50	19	94	50	32	96	28
94	92	66	33	68	34	33	28	86	66
68	62	86	13	36	28	55	64	50	84

5	3	2	3	5	9	1	4	1	9
7	1	4	9	1	6	7	3	3	6
2	7	7	2	3	1	6	6	9	8
99	66	94	78	60	32	48	86	24	36
66	86	50	44	76	92	26	14	78	50
76	66	75	72	44	79	92	42	66	44
84	84	60	94	92	46	50	24	50	77
38	96	33	36	24	36	77	34	88	24
26	36	88	64	62	82	80	28	76	94
42	16	64	24	84	94	77	98	93	50
64	79	14	50	16	66	48	82	46	33
84	22	42	88	34	50	28	78	36	80
12	64	28	42	46	44	94	96	18	44
50	96	34	28	74	32	86	78	62	94
77	50	96	64	50	84	32	88	50	34
95	22	64	92	88	50	94	64	22	50
20	44	50	34	33	44	66	88	98	20
50	32	88	50	68	96	50	32	28	77
88	82	76	20	96	73	22	28	50	86
92	66	24	88	62	62	86	50	88	50
37	96	48	76	32	26	34	33	42	66
22	50	38	48	48	78	92	42	32	94
78	88	82	82	74	82	50	66	88	73
62	22	94	50	28	36	60	12	66	84
14	50	72	99	66	50	77	96	78	14
48	77	82	64	82	22	48	64	88	38
32	93	50	33	50	77	26	50	94	96
62	35	77	12	44	86	66	44	64	79
86	73	62	92	78	36	76	32	74	28
32	28	33	62	17	68	46	68	50	44
64	12	22	78	92	50	34	12	33	50
96	82	66	50	55	44	50	42	40	33
48	66	88	33	80	96	77	28	88	97
72	84	94	20	44	46	95	92	94	80

Experiment XXV.

Comparative Estimation of Fatigue at Different Periods or after Different Kinds of Work.—Either Test A or Test B of Experiment XXIV. may also be used to compare the amount of work done at different times of the day or after various kinds of other work. Thus the student may do a page of calculations or two pages of letter cancellation in the early morning, and again in the afternoon and late at night, timing himself on each occasion. Or he may on one day do the test after a morning at hard study, and on the next day he may do a similar test after a morning spent in vigorous physical exercise. As already hinted, he must be alive to the likelihood of improvement due to practice, especially in the more difficult work of calculation. For example, one subject made the following scores in quarter-hour tests at the various times mentioned :—

Tuesday	2.30 p.m.	(feeling fatigued)	108	answers right.
„	7.30 p.m.	(„ fresh)	152	„ „
Wednesday	11 a.m.	(„ fresh)	179	„ „
„	2.30 p.m.	(„ fatigued)	161	„ „

The improvement in the score for the second test cannot be ascribed merely to the subject's being more alert mentally. Practice certainly is partly responsible for the improvement, and probably even for the further improvement shown in the third test. In the fourth test, even if there is still some improvement due to practice, the fatigue invariably felt by this subject at this time of the day showed itself by the first drop in the score.

As a partial check upon the effect due to practice the student can arrange the tests as follows. Suppose he wishes to see whether a morning at study or a morning's

strenuous physical exercise fatigues him more for arithmetical calculations. He should do half-an-hour's work at Test B after the morning's study; on another day he should do the test after the physical exercise; on two subsequent days the order should be reversed, the first test coming after a morning's exercise and the second after a morning's study. Thus the effect of practice will favour the test after study in the first pair of tests, and the test after exercise in the second pair. We cannot, however, assume that the effect of practice will be the same in both cases. It will probably be greater in the second test than in the fourth. But the results may be such that some inference is possible in spite of the complicating effects of practice. Thus suppose the figures are as follows:—

Test	I.	After study	100
,,	II.	After physical exercise	130
,,	III.	After physical exercise	135
,,	IV.	After study	165

Such a record may probably be interpreted as follows. Score IV. improves on score III. much more than score III. does on score II. Now it is very unlikely that practice effects will show themselves more in the fourth period than in the third. We may therefore suppose that the superior score of test IV. is due to the fact that the subject is less fatigued for arithmetical work after a morning's study than after a morning's severe physical exercise. That score II. is greater than score I. in spite of this may be ascribed to the great improvement in the test work due to practice at this early stage.

For more reliable results, however, the above series should be repeated, this time in the following order: Test I., after physical exercises; test II., after study; test III., after study; test IV., after physical exercises. Or the

student may practise the method on several occasions when feeling quite fresh and at about the same time of the day, until no further improvement is apparent and the scores maintain a fairly constant level. Naturally, the easier the test the more rapidly will such a stage be reached. The test may then be applied to discover the most efficient hour of the day for such work without fear of any complicating effects due to further practice.

In so far as the student wishes to know how far the variations in the amount of work are due simply to his varying mental condition according to the time of the day, he should as far as possible let the time preceding the tests be spent pretty much alike. It would obviously be unsatisfactory to do a test at 12 midday after a strenuous morning's work, then another at 4 p.m. after an easy afternoon, and then to suppose, if the scores are equal, that he is normally as mentally fit at 4 in the afternoon as at midday.

For a further discussion of the results of Experiments XXIV. and XXV. see p. 151.

CHAPTER XII.

EXPERIMENTAL TESTS OF GENERAL INTELLIGENCE.

Experiments XXVI. and XXVII.

In the case of several of the tests already given in this book, for example "restricted associations" ("opposites" test), mirror-drawing, deletion of letters, and prolonged memory for nonsense syllables, it has been found that the most intelligent children in a given class do better than the less intelligent. In other words, if a list of a class of children is drawn up in order of general intelligence as estimated by one or more of the teachers, and a second list is drawn up showing the order of merit in the performance of the test, then these two orders show a decided correlation. For this reason, some psychologists claim that such tests may be used as a means of estimating "general intelligence."[1]

There are given below two further examples of tests which have also been found to correlate highly with general

[1] Unfortunately I have no space for an adequate discussion as to the significance of the vague and inexact term "general intelligence." But we all have a rough idea as to what it means, though probably it should have no place in a scientific psychology. It may be that one of the services of mental tests will be to analyse and define more exactly the various constituents of that which at present we indicate by this vague term.

intelligence. The student may, if he wishes, read the discussion of the purpose and method of intelligence tests (Part II., Chapter X.) before doing the experiment.

These tests are primarily intended for use with children, but if they are to be so applied it is highly desirable that the experimenter should first undergo the experiments himself, in order that he may realise fully all that is involved in the performance of them.

Experiment XXVI.

Completion Test.—Fill in the blanks in the passage given below so as to make the whole into a consecutive and sensible piece of prose. Piece A is suitable for adults, Piece B for children. A time limit should be given, say fifteen minutes, for the adults' piece. When a whole class are doing the experiment it should be stopped as soon as one subject has completed the paragraph. The whole paragraph should be read over before the filling in of blanks is begun.

Piece A.

About three-fourths.....England belong to the wage-earning..... .....events when.....fed, ...housed and educated, they.....that nervous energy which.....material of business ability. Without.....of their way.....or unconsciously competitors for.....business command. The ordinary.....ability, generally.....foreman, from.....to be a manager and..... with his employer. Or having.....of his own.....one of those small shops..... their own in a working man's quarter,.....chiefly on credit,.....wife.....day while.....to it. In.....or..... | .....capital till

.....small workshop or factory. Once..... good beginning he... .....banks eager..... credit.

A blank generally indicates the omission of *several* words.

The full passage is printed on page 163. Each blank suitably filled in should score one mark. Blanks divided with a line thus | score one mark for each section appropriately filled. Of course the words given in the full passage are not the only ones which will satisfactorily fill the blanks. The student must be careful, however, to mark only for words which not only make sense of the sentences in which they appear, but which are also consistent with the passage as a whole.

Piece B.[1]

Before giving such a test as this to children a specimen piece should be done with them on the board to show them exactly what they have to do.

One ..... the eagle went ..... the other ..... to see which could ..... the highest. They agreed ..... he who ..... fly the ..... should ..... called the strongest bird. All started ..... the same ..... and flew ..... among the cl..... One by ..... they ..... weary and re....., but ..... eagle ..... upward and ..... un..... he ..... a ..... speck ..... the heavens.

When he ..... back, ... others .... for him; and ..... he touched ...., a linnet ..... off ..... back, where .... hidden, and ..... that ..... himself .... strongest ..... "I ..... stronger ..... the .....," said

[1] From Whipple, *Manual of Mental and Physical Tests*, p. 448.

...., "for not ..... did I .... high, but ..... he .... downward ..... I left ..... hiding .... up a little ....." At ..... boastful ....., the .... their heads, ... council .... matter. After ..... long .... decided ..... the .... the ..... bird, ... not only ..... he ..... so high but .... the..... ..... well.

To ..... day ..... plumes .... are ..... emblems of ..... str..... ..... cour.....

In this piece each *line* of dots indicates that a word is missing, and each appropriate word filled in scores one mark. The time-limit in this case should vary according to the age and intelligence of the average child of the class tested. Time should be given for the best children just to complete the test as well as they are likely to do.

Experiment XXVII.

Apprehension of Numbers.—Each of the squares on the next page contains a group of dots varying in number from four to nine. A series of similar squares should be marked out on paper, enough to make with those overleaf a total of thirty squares. Each group of dots should appear an equal number of times, but the order should be varied. Let your partner use the set of squares that you make, you using the set that he has prepared.

The task is to apprehend the number of dots in the successive squares as rapidly as possible, calling the numbers out aloud to your partner.

Your partner must take down what you say, in order that your accuracy may be tested subsequently.

Apprehension of Numbers.

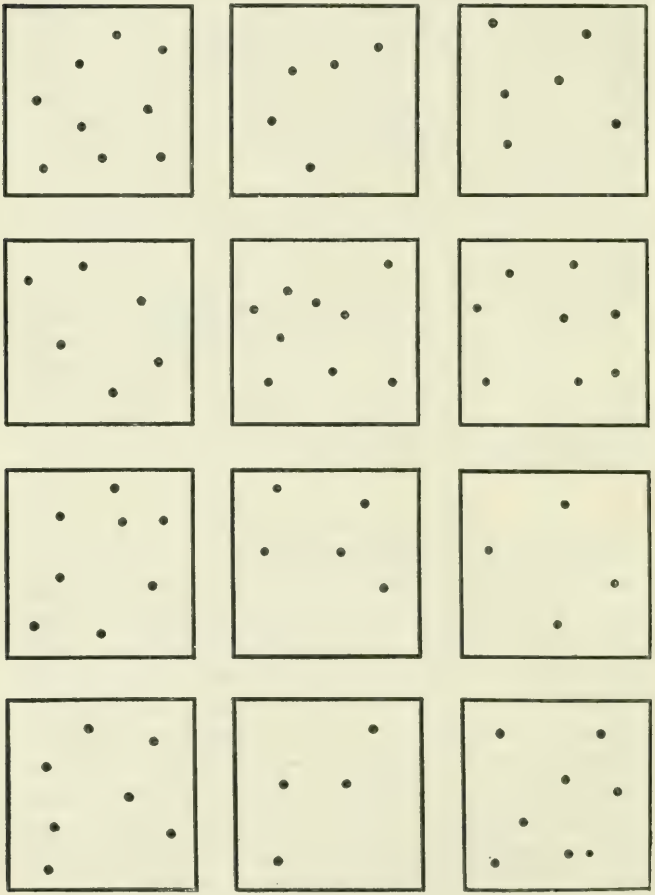


Fig. 5.

It should be clearly understood that the dots are not to be counted individually any more than the student finds necessary. As far as possible the group should be apprehended as a whole or as an arrangement of two or more minor groups each of which can be taken in at a glance.

Your partner should also time you, and note down the number of seconds required to do all the thirty squares.

If a whole class are doing the experiment they should work in pairs as above. The test should be stopped when any student has finished. One mark is to be reckoned for each group of dots correctly apprehended.

The partner now becomes the subject, the previous subject noting down his answers as above. The same length of time should be given as was taken by the first subject (or by the first section of the class).

If a comparison of results is desired proportionate allowance should be made for any student of the second group who finishes the test before the allotted time is up.

For the *application of the test to children* it would be well that the squares of dots should be marked upon cards. Each card may contain several squares; eight on a card would make a convenient size. As each card is finished with, it is to be removed, and the groups of dots on the next card proceeded with straightway. This is a test which can only be applied satisfactorily to one child at a time, and the same set of cards should be used for all the children whose performances are to be compared.[1]

See p. 163 for a discussion of the results of Expts. 26 and 27.

[1] Mr. C. Burt, from whom I borrow this test, used a pack of fifty cards, only one group of dots being on each card. The children had to deal the cards, calling out the number of spots upon each as they went along. The test correlated with estimated intelligence to the extent of 0·64, the reliability coefficient being 0·91. See *Journal of Experimental Pedagogy*, Vol. I., p. 102.

PART II.

CHAPTER I.

ASSOCIATION AND REPRODUCTION OF IDEAS.[1]

Experiment I.

Factors Determining Association or Recall.—The general law of the association of ideas may be briefly expressed as follows: when two ideas, A and B, have been connected by unity of interest, or when they have been attended to together, they tend to recur together, *i.e.* if A recurs it tends to call up B, and vice versa.

There are certain conditions or factors which help to determine whether such an association will be strong or weak, whether it will last for a long or only a short time, and the likelihood of its recurrence. For example, the more frequently we attend to A and B together the stronger the bond between A and B becomes; the greater our interest in A and B the stronger will be the bond of association; and the more recently we have attended to A and B

[1] In connection with this chapter the student is recommended to read some general account of association, *e.g.* Stout, *Groundwork of Psychology*, Chapters VII. and XI.; Loveday and Green, *Introduction to Psychology*, Chapter XIII.; Dumville, *Child Mind*, Chapter III.; Brackenbury, *Primer of Psychology*, Chapter V.

together the stronger is the association likely to be at the present moment.

Now a given idea may have been connected with many ideas at different times in our past experience. Thus the word *book* has been associated with many different books. When the word *book* is seen there may therefore be a competition, as it were, of various associations each striving to come into consciousness. Why is a certain one victorious over the others? Why did the word *book* call up exactly the idea it did in this experiment?

To explain this we must refer to those factors or conditions which affect the strength of associations and help to determine what ideas are recalled.

We select five of the most important factors. Probably it will be found that most of the associations the reader obtained in the experiment can be explained by reference to one or other of these factors. It should, however, be remembered that the list is not exhaustive.

(1) **Recency.**—Apart from the influence of other factors to be mentioned presently, an idea tends to recall that idea with which it has been most recently associated. Thus, *book* is likely to suggest the book you have most recently been reading, perhaps this book itself.

(2) **Frequency.**—Apart from the influence of other factors an idea tends to recall that idea with which it has been most frequently associated in the past.

This factor may overcome the influence of recency. Thus in response to *green* you may have thought, not of the last green thing you saw, but of grass, because of the great frequency of the association of grass and greenness.

Of course it is possible that these two factors should act together and support one another. Thus if grass happens to be the last green thing I have seen, as well as the one I

have seen most frequently, it is still more likely to be thought of when the word *green* is presented.

(3) **Intensity of Interest or Feeling at Time of Formation of Association.**—Other factors apart, an idea tends to recall the thought of some thing or experience which was associated with it in the past and which was exceptionally interesting. In other words, the more intensely interesting a certain experience is, the more likely is it to be retained in the memory and the more readily will it be recalled. Thus, if I had a serious operation ten years ago, I am quite likely, in response to the word *doctor* in the experiment, to think of the doctor who performed the operation, even if I have seen other doctors more recently and more frequently.

Again, it is possible that all these three factors will act together in some cases. Thus *bicycle* may suggest my own latest bicycle, which I have seen and ridden more recently and more frequently than any other bicycle, and the one on which I have had my most enjoyable rides or a very exciting accident. On the other hand, this factor of Interest may conflict with one or both of the two previous ones. I may have had an accident when I was riding a friend's bicycle, and this may now be thought of when I see the word *bicycle*, although I have ridden my own bicycle more frequently and more recently.

These three factors of Frequency, Recency, and Intensity of Interest all concern the past. But the conditions present at the moment of recall or reproduction also act with them in determining the line that association shall take. This leads us to mention a fourth factor.

(4) **The General Trend of Mental Activity at the Time of Recall.**—"Those objects tend to be ideally reinstated which are relevant to the general trend of mental

activity at the moment of recall. If our minds are occupied with scientific discussion the word *proofs* will suggest one group of ideas; if we are engaged in preparing a book for the press it will suggest something quite different." [1]

In Experiment I. the word *friend* may start me thinking about a certain friend. Then the word *bicycle* may determine that I should think of my friend's bicycle.

We can arrange conditions in such a way that the effect of this general trend of mental activity is very clearly shown. Thus by arousing certain ideas in the mind of a person we may be able to determine the line on which associations shall take place. Suppose, for example, that I talk to a class of children about country fields, and cows, and the danger of getting tossed, and then show the children the letters B–LL, they are likely to think of "bull." If, on the other hand, I talk to them of the coming of summer and cricket, they are likely to complete the word so as to read "ball"; while if I say to the children that it is nearly twelve o'clock and time to go out of school the letters are more likely to suggest "bell." [2]

(5) **Dominant Interest.**—We have seen that the general trend of mental activity at any moment helps to determine what associations shall take place at that moment. Now I may become interested in some topic to such a degree that there is a constant tendency for associations to take place in a way that fits in with that special interest, even when I am not at the moment concerned with that particular topic.

Suppose my chief interest is in psychology. Then the word *book* is quite likely to suggest a psychology book, even

[1] Stout, *Manual of Psychology*, 3rd edition, p. 565.

[2] In these examples we have approached the topic of Apperception, for experiments upon which unfortunately we have not space.

though I have read other books more recently and more frequently, and though at the moment when I see the word *book* I am not thinking about psychology. This last fact indicates the distinction between factors IV. and V.

Furthermore, there may be other books, novels perhaps, which I have found more intensely interesting as individual books than any psychological books. But they are not linked together by a wide dominant interest as is my psychological reading. Herein appears the distinction between this factor of Dominant Interest and factor III., Intensity of Interest.

Classification of Associations.—The student should now attempt to classify the associations he observed in Experiment I. as exemplifying one or other of the factors mentioned. In most cases no doubt he will find that more than one factor has been at work. Some associations he may not be able to classify at all, for the list, as already stated, is not exhaustive.

With a series of odd words such as those given for the experiment the student will probably be struck by the great influence of the factors of frequency and recency. It would be interesting to compare the results of Experiment I. with those gained in the following experiment.

Experiment in Continuous Series of Associations.—Write a list of thirty words as quickly as you can, starting with the word *town*. Write down whatever comes into your head. It is especially interesting if a group of people perform this experiment together and afterwards compare lists. The factor of dominant interest has a better opportunity of showing itself in a continuous list of this nature and often betrays marked individual differences between the persons taking part.

In *continuous thinking* the associations are more com-

pletely determined by the interest and purpose of the moment than by such factors as recency and frequency. Yet underlying this will be the influence of the other factors. In the case of the successful thinker, irrelevant ideas—stray associations due to recency or frequency, but of little value for his present purpose—do not frequently occur. In the case of the genuine orator appropriate ideas flood his mind, the interest and purpose of the moment dominate all his thoughts. With the slovenly inefficient thinker, on the other hand, the first three factors mentioned are not adequately controlled by the interest and purpose of the moment. Hence the irritating irrelevances frequently introduced.

Educational Significance of Experiment I.—This experiment has been given chiefly as an exercise in self-observation and as a means of studying concrete cases of the workings of these conditions determining associations, rather than because of any direct bearing of the experiment upon matters of educational interest. Yet we may consider the comparative importance of the first three factors in the processes of learning.

Recency is the factor upon which the crammer relies to ensure recall, and it is obviously the least valuable from the teacher's point of view, as it gives no guarantee of permanent retention.

Intensity of Interest is the factor of which, above all, the teacher should seek to make use in fixing an association. The more intensely interesting an idea is made, the longer it will be retained and the more readily it will recur. It should be noted that there is a tendency for the *first* impression of anything, or the first occurrence of an idea in connection with another, to be especially interesting and lasting, because of the element of novelty, a fact which

makes it all the more important that such first impressions or associations should be correct. Thus one disadvantage of a child's trying to guess say the meaning or spelling of a new word is that it may set up a wrong association with the word which may continue even when the teacher's correction has been forgotten.

A poor substitute for the factor of Intensity of Interest, but sometimes perhaps a necessary one, is that of Frequency —used when we seek to fix an association by constant repetition.

The Use of Experiment I. in Schools.—The experiment is one which can be carried out upon school children, but of course the experimenter must be cautious in accepting the explanations of children as to why their various ideas were suggested by the given words. But if the test words are suitably chosen, the words suggested by these to the children may throw an interesting side-light upon the contents of their minds. If the teacher is content merely to have the list of words suggested by the given words, without any explanations as to why they occurred, the experiment may be done with a whole class at once, the children being asked simply to write down the first word that comes into their heads, after each word read out.

If, however, reasons are wanted the children should be taken individually, extreme care being taken not to suggest any reason to the children why any idea occurred to them by putting them leading questions. It is a good rule to avoid, whenever possible, any question that can be answered simply by "yes" or "no." By taking the children individually there is the great advantage that the experimenter will be better able to judge whether the child is giving the first word that occurred to him, or stopping to think of a "good" word to give.

Experiments on Restricted Association.—Mention may here be made of experiments in which the associations are guided or restricted in a way which is not the case with the comparatively "Free" associations in Experiment I. Restricted associations are guided by some given principle, and we have in them the elements of rational thought. Thus while some writers class these tests under "Restricted Association" others call them "Reasoning Tests."

A list of objects– *e.g.* horse, table, gun—may be read out to the class, the children being asked to write down some quality possessed by each object, opposite to its name, or some word describing the object; or they may be asked to name some part of the object, *e.g.* tail, leg, barrel (*Whole-Part* Test), or some wider class of objects to which the given object belongs, *e.g.* animal, furniture, weapon (*Species-Genus* Test); or the name of some class of object may be given and the children asked to give examples of the class, *e.g.* furniture—table, animal—horse, city—London (*Genus-Species* Test). Again, words such as good, heavy, full, first, day, may be read out and the children asked to give the opposite of each word (*Opposites* Test).

In all such experiments the teacher must first make sure that the children understand what is required. A number of examples should be done on the board before the class, and a few easy preliminary test questions be given afterwards. For the actual experiment a list of twenty or thirty words may be written down on one side of a sheet of paper and the child told to write the required word next to it. The experiment should be stopped as soon as one child has completed the list, although the relative speeds of writing will thus complicate results somewhat. Several investigators have found that the Genus-Species, Species-Genus and Opposites Tests, when given with a time limit,

correlate with general intelligence, *i.e.* the most intelligent children give the greatest number of appropriate words. The use of such tests as tests of general intelligence will be referred to later, and the teacher is advised to defer all attempts to apply them till a later stage.[1]

[1] For a more detailed description of similar tests see article by Vickers and Wyatt, *Jour. of Expl. Pedagogy*, Vol. II., Part III.; or article by Wyatt, *Brit. Jour. of Psych.*, Vol. VI., Part I.

CHAPTER II.

IMAGERY.

Experiments II., III. and IV.

It is of course very difficult, perhaps strictly speaking impossible, to say whether a visual image is more or less vivid than an auditory image. But if the reader will repeat the tests of Experiment II. with various imagined objects he will soon get an idea as to where his imagery is strong and where it is weak.

People vary enormously in this respect. Many, for example, will find that they can get no images of taste or temperature or even of smell. Educationally the most important kinds of imagery are visual and auditory. The subsequent experiments on memory will bring out more clearly the use of such imagery in memory work.

Images also often have an important influence upon our appreciation of, and understanding of, descriptive literature. The passages descriptive of natural scenery will probably be more appreciated by those who possess vivid and rapid visual imagery. Where this is lacking, the sound of the words of the poem, their rhythm, and their meaning, interpreted in terms other than imagery, are probably the predominant factors in determining whether the poem is liked or not.

Individuals seem to vary greatly as regards the extent to which imagery contributes to the enjoyment of poetry. Some persons, the present writer included, derive great pleasure from a poem like the selection from Wordsworth

in Experiment IV. with the use of but little imagery. On the other hand, some as yet unpublished experiments of the writer seem to show that a number of people depend to a large extent upon their imagery for the enjoyment of such poetry. These persons usually visualise with ease and rapidity. In the case of those whose imagery is weak a deliberate effort to visualise causes delay in the reading of the poems, and the rhythm necessarily suffers.

The student should also observe carefully the various ways in which imagery may be of service in every-day life, *e.g.* in recalling the appearance of a map and so more easily finding one's way about a strange town, in deciding on a colour scheme for a room or a costume, or in recalling the tone in which a person said something in order to decide whether it was meant in a friendly way or not. He should observe also the way in which he uses imagery in his continuous thinking. Modern researches in psychology have shown that highly elaborate thought processes may proceed without much use of imagery and that sometimes imagery may prove a hindrance. Frequently, however, images are introduced and used profitably when there is a hitch in the process of thought. But, apart from this, the value of the power of imaging sights and sounds would seem to be sufficiently great to make it undesirable that it should be allowed to decay.

There is considerable evidence to show that the power of imagery may be cultivated by practice and lost through neglect. Thus children in general seem to have vivid visual imagery,[1] and so have most women. Many men,

[1] It may be worth while for the teacher to bear this fact in mind. "The teacher who can himself image clearly when he wishes will often find in doing so a key to the minds of the children whom he has to instruct."—Loveday & Green, *Introduction to Psychology*, p. 177.

however (most of whom find it less useful than women do and therefore practise it less), have only vague visual images, especially those who are much given to abstract thought. But artists and others who practise imagery retain the power of vivid imagery.

Those whose visual imagery is much more vivid than the other kinds are said to belong to the visual type and are called "visiles." If the sound images are much the most vivid they belong to the auditory type and are called "audiles." Most people seem to belong to a mixed type.

The use of imagery in memorising will be dealt with in Chapters VI., VII. and IX.

The Use of Experiments II., III. and IV. in School.—It would be well if some guidance were given to scholars in the use of imagery, particularly to children in the higher classes. But the difficulty of securing reliable introspection makes it somewhat risky to draw inferences as to types among young school children on the basis of results gained by Experiments II., III. and IV. Some investigators, however, confidently assert their belief in the reliability of the testimony of children as to their imagery, even when the subjects are as young as ten years, and certainly intelligent children of twelve years and upwards should prove fairly satisfactory subjects for the tests, if suggestion is carefully avoided.

More reliable objective results as to types of imagery will be obtained from the memory experiments. But with children of about twelve and upwards Experiment IV. at least may provide interesting and valuable results, poetry suitable to the age of the children being chosen. It should be preceded by some questions and illustrations, such as those of Experiment II., to make sure that the

child understands what is meant by the various forms of imagery. The experiment may be performed in groups, but this should certainly be supplemented by some tests of individual children taken alone. In this way the experimenter can satisfy himself more certainly that the images are really experienced by the children. He must be very careful to avoid suggesting any image by the form of his questions. These should be quite general, *e.g.* "What images did you have?" or "What did you picture or hear in your mind?"[1]

In the group experiments the passages should be read and then the children should be asked to write down the images they had when hearing the passages. It will add to the interest of the results if the children are asked to state whether they found the pieces pleasing or not. Some light may thus be thrown upon the question as to what extent the appreciation of certain poems by the children depends upon the presence of imagery. The child will very likely hesitate to say that he does not like a piece selected and read by his teacher.[2] The teacher should first reassure him upon this point, saying that he does not mind whether the child likes them or not, and that he is giving several pieces, some of which he does not like himself.

Finally he should draw up a list showing the number of

[1] For an interesting account of such an experiment upon schoolboys see E. A. Peers, "Imagery in Imaginative Literature," *Journal of Experimental Pedagogy*, Vol. II., Nos. 3 and 4.

[2] This all depends upon the relations between the teacher and his pupils. If these are very frank and friendly the difficulty will be very much lessened. Under such circumstances it has not been entirely unknown for boys to suggest in a friendly manner some improvement in the lessons given or even in the teacher's method of teaching.

images of the various kinds which each of the boys declares he has had. Of course one cannot get rid of the possibility that these totals may be affected by the comparative slowness of some of the boys to detect imagery or to recall it. But this is likely to affect all kinds of imagery, except in so far as one is more vivid and frequent than the other. Hence the comparative totals of, say, visual and auditory images will not be affected by this difficulty.

CHAPTER III.

ATTENTION.

Experiment V.

Concentration of Attention.—The first purpose of this experiment is to bring home to the student how very difficult it is, even for an adult (and still more for a child), to keep the attention fixed upon the same object for more than a very few moments. On the average there tend to be four or five fluctuations of the attention in the minute in Test A, some people having as many as ten or twelve, though a few manage to avoid any fluctuations for as long as a minute. In these last cases, however, the subject[1] has generally followed the method of Test B to some extent, *i.e.* he has thought things *about* the figure. In Test A these should really be reckoned as fluctuations. This setting oneself new questions about the figure makes an enormous difference to the possibility of concentrating the attention. Half of one class of sixteen students reduced their fluctuations of attention to 0 in Test B, the total number of fluctuations for the whole class being 46 in Test A and 19 in Test B.

What is the significance of this? It indicates the crav-

[1] Throughout this book the term "subject" is used to signify the person on whom the experiment is performed. The "operator" or "experimenter" is the person who performs the experiment upon the subject.

ing of the human mind for change. We are all familiar with the man who always takes the same point of view in reference to almost all topics. For this very reason he fails to hold our attention, except perhaps through a great effort on our parts for the sake of politeness, and the man is accordingly recognised as a bore. On the other hand, the man who is continually seeing and suggesting new points of view and new questions even upon threadbare topics stimulates our interest and attention and is voted an interesting man. In these two opposite cases we have further examples of the effects of the law of attention illustrated by the experiment.

The mind is ever seeking some change, and cannot even with an effort keep the same idea before itself continuously. Thus, if the teacher wishes to hold the attention of the children to one object or idea for any prolonged period, he can only do so by suggesting new points of view, and new questions about it. Thus can the mind be led to play about the same central topic for some time.[1]

Experiment VI.

The Control of Attention.—Experiment VI. illustrates the rule that in order to keep any given idea, X, out of the mind it is best to supply the mind with a new and attractive idea, Y, to take its place. A merely negative attitude is insufficient. The mind insists upon some object of thought in reference to which it can be active. One subject, by having a positive idea on which to concentrate, reduced the number of times his mind wandered to the "forbidden" topic from 8 to 2, another from 21 to 11. Many subjects have fewer fluctuations of attention to the forbidden topic than the numbers mentioned. But

[1] On this topic see James, *Principles of Psychology*, Vol. I., p. 420.

unpractised subjects, in this experiment as in the preceding one, are apt to pass by a few fluctuations of attention without giving the prescribed sign. For a class of beginners in Experimental Psychology, twenty in number, the total number of observed movements of attention to the forbidden topic was as follows: during the first minute, 64; during the second minute, with the aid of an idea upon which to concentrate, 30.

In doing the experiment the subject would realise how the very suggestion that he should not think of the holidays led him to do so. Teachers will thus see the inadvisability of merely telling children *not* to attend to this or that. Rather should they seek to emphasise the idea which should take the place of the thought of the forbidden object. Not only will this be more likely to be effective with the child whose mind is wandering to some forbidden topic, including external objects of attraction, but the teacher will thus avoid suggesting any such topic to the other children.

Experiment VII.

The Division of Attention.[1]—It would obviously be a very valuable capacity if we could attend to several things at once. Some people do appear to have a special "gift" for keeping a number of things in mind at the same time, while every teacher is familiar with the child who seems incapable of holding in mind two items of instruction at once. The child may, for example, remember to march properly, but in that case he does not hold up his head, or if he succeeds for a time in holding his head properly, he straightway forgets about the marching.

Psychologists have questioned whether it is ever possible

[1] See also James, *Principles of Psychology*, Vol. I., p. 405.

to attend to two distinct mental operations at once. Experiment VII. is intended to bring out clearly some facts bearing on this problem.

In Experiment VII., if the subject were quite able to do the two things, counting and writing letters, at once, without one interfering in any way with the other, then in the combined Test C he should score as many figures as he counted in Test A, and as many letters as he wrote in Test B, for he had the same length of time, viz. one minute. That he should do this is, of course, very unlikely. If, on the other hand, the subject were never able to attend to both operations simultaneously at any moment during Test C, his score for counting is likely to be no more than half what it was in Test A, and his score for writing letters will be only half what it was in Test B.

For example suppose in Test A he counted 60 odd numbers and in Test B wrote down 40 letters; now if in the combined test he scores exactly half these numbers (30 odd numbers counted and 20 letters written), this may mean that his attention has simply been fluctuating from one thing to the other and on no occasion has he been attending to both operations at once. This is assuming that during Test C he divides his attention equally between the counting and the writing. Probably, however, the subject will find that he has neglected one and favoured the other. In most cases there seems to be a tendency to favour the writing at the expense of the counting, probably owing to the fact that the paper and the previously written letters are there before his eyes and help to hold his attention.

If, however, in the combined test the subject scores more than 30 numbers without lessening proportionately his sum of 20 in letters (or if he scores more than 20 letters without lessening proportionately his score of 30

numbers), this suggests that at some moments he has been doing both things at once.

Some subjects are evidently able to do this. But it does not seem to be because the attention is split between the two operations. It appears rather that one operation, say writing the letters, is started with attention concentrated upon it, and then while the subject is writing A, B, the attention takes in at a glance, so to speak, three or four following letters; he then continues to write the letters C, D, E, F mechanically while his attention turns to the counting. Thus what may appear at first sight to be a division of attention may be one of two things:—

(1) a very rapid fluctuation of attention from one thing to the other;

(2) a partial "mechanisation" of one of the two operations.

All this does not contradict the statement with which we started, viz. that some people are much better able than others to do two things at once. We see, however, that probably what they do is to reduce one of the two operations to a habit, at least to a kind of temporary habit. This power of mechanisation is itself valuable and is possibly one element in what we call "general intelligence." Some mental defectives seem especially weak in this respect.

In Experiment VII. I have found some subjects so flustered by the attempt to do two things at once that they actually do worse in *both* operations than they would have done if they had given half of the time to each. It may be of interest to the teacher to find out which of his pupils are best able to do the combined test, and to note whether those who do best in the test are those who show most alertness in the ordinary school work.

Individuals vary in the kinds of things which they are able to reduce to a mechanical habit. Thus child A may

learn to count mechanically more rapidly than child B, yet child B may more easily mechanise certain drill movements, thus leaving the attention free to attend to and learn more complicated movements.

In Experiment VII. the subject was told to count odd numbers, instead of every number, expressly for the purpose of making the counting less mechanical. If the subject tries the experiment again, counting every number—1, 2, 3, etc.—this time, he will realise how much more attention he can now give to the writing work.

Experiment VIII.

The Attraction of Attention.—Suppose a list of words is read out to a group of about twenty people and they are asked to write down all they can remember. If we then count how many people have written down the first word, how many the second, how many the third, and so on, we generally get a list somewhat as follows:—

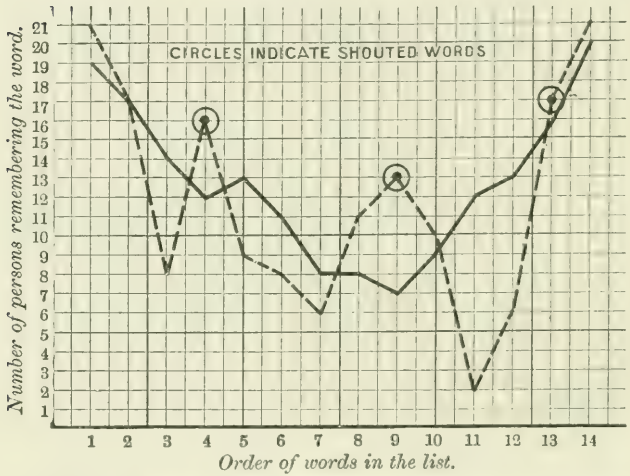
Order of word in the list	1 2 3 4 5 6 7 8 9 10 11 12 13 14
Number of persons who remembered the given word	18 17 14 15 13 11 8 8 9 12 15 15 18 20

This gives us a curve as in Fig. 6 (plain line), the special characteristic being the great "sag" in the middle. The nature of this average curve is due to several causes, the most important being the fact that the words just heard at the end are naturally recalled at once and written down while fresh in memory, while on the other hand the first word or two on the list receive complete and undivided attention when they are heard.

When, however, certain words are emphasised (as in

Experiment VII., Test A) by being pronounced much louder than the others, their score is considerably increased and the curve is modified in a way indicated by the dotted lines in the curve above. This is the graph of an actual experiment with the given words of Experiment VIII.

CURVE SHOWING MEMORY OF A LIST OF WORDS.



Plain line—average curve when words are read out in an ordinary voice.

Dotted line—actual curve of an experiment: points with circles round them indicate scores of words which were shouted.

Fig. 6.

Even if the loud-spoken words do not score more than all of the other words[1] (as indeed they are quite likely to do), they tend to score much more than is usual *for words in their position*; hence the value of a normal curve with which to compare the curve of the scores of Experiment VIII.

[1] With the exception of the first and last.

Now it may be thought that the high scores of the loud-spoken words are due simply to their loudness. It is indeed true that attention is attracted by the more intense stimuli, other things being equal; but that this is probably not the sole cause of the greater score of these words will be shown by Test B of the same experiment. Here the *whispered* words tend to be remembered better than the other words —or at least better than is normally the case with words in their position in such a list. Thus in a class experiment the average score of the whispered words was 13, that of the other words (excluding the first and last) only 9. Yet in the case of the whispered words the stimulus is actually *less* intense, so that the factor or "law" of intensity is working against them.[1] The fact is that in both experiments *attention is attracted by the sudden change* either to whispering or shouting, and, in accordance with a well-known psychological law, that which is attended to most completely is best remembered.

The plotting of such curves is, of course, only possible where the experiment is done by a group of students. If the reader simply does the experiment upon one subject he may get some estimate of the effect of this law as follows. The first and last words of both lists (Tests A and B) should be ignored as being especially liable to be remembered owing to their positions. This leaves in each list twelve words—nine read in an ordinary voice and three shouted or whispered; adding the lists, we get eighteen ordinary words and six "change" words. The reader can now calculate what proportions of each of these classes were remembered by his subject.

[1] Thus even if, as sometimes happens, the whispered words only retain a normal position in an average curve, this means that they have somehow made up for the loss of intensity of stimulus. This itself is evidence that some other law is at work.

This experiment illustrates the law of the attraction of attention by a change from a somewhat different point of view from that of Experiment V. There we were concerned with voluntary attention; here we are concerned with a more passive aspect of attention.[1] From this point of view the law can be applied to the manner as well as to the matter of teaching. It is the psychological justification for the use of variation of tone and gesture in order to hold the attention, as well as for the introduction of some variety and novelty in material.

[1] There is still, of course, voluntary attention, but the shouting or whispering forces some words upon the attention, and so an element of passivity is introduced.

CHAPTER IV.

ECONOMICAL METHODS OF LEARNING.

Experiments IX. and X.

Individuals vary greatly, but most readers will probably be surprised at the extent to which the "whole" method of learning succeeded with the poetry, unless they found the pieces hard to understand. In experiments of my own, using the given pieces, about two-thirds of the students found the "whole" method superior, the superiority being especially marked when the students wrote out what they remembered of the poems a week after they had learned them. It would be well for the reader to add this additional test, for it is in prolonged memory that the "whole" method has generally been found to show its superiority most markedly. It should be noted also that practice in the use of the "whole" method reveals its superiority still further.

At the same time I have found some students who seem to find the sectional method the better. The various characteristics which seem to make the "whole" method usually superior do not seem to affect all equally. In general, previous experimenters seem to assert more unreservedly the superiority of the "whole" method than I have done above. One investigator found the superiority of the "whole" method much greater when he used poems considerably longer than those given for use in the present

experiment, extending even to 240 lines. But probably many persons would get discouraged in attempting to learn such long poems by the "whole" method. They would feel they were making no progress.

The Advantages of the Respective Methods.—Let us consider the various points involved in the respective methods when applied to poetry or continuous prose. In the sectional method there is obviously a danger of leaving weak points between the sections, even if the sections as such are well known. Hence the frequency with which children forget the beginning of "the next verse" even though they are able to finish each verse when told the first word or two.

In the repeated reading of one section the mind passes from the end of the section back to the beginning of the same section, instead of to the beginning of the next section, as is required. Thus there is a possibility of wasted energy and of wrong associations. With the "whole" method there is no such waste. Further, the general meaning of the poem is better kept in mind by the "whole" method.

On the other hand, as one reaches a stage at which nearly all the lines are known it certainly appears waste of time to go over the whole poem in order to strengthen the few weak spots. But this added repetition will tell when the attempt is made to recall the poem after a considerable lapse of time. Thus it is not surprising that the superiority of the "whole" method has been shown to be more marked when the memory of the poem is tested after some days or weeks.

The nature of the material to be learnt will obviously affect the comparative values of the two methods. The less the poem forms a unity, the less it is dominated by

one or two leading ideas, the less will be the comparative efficiency of the "whole" method. In such material as a long vocabulary, say of English and foreign words, there is of course no such unity. And in such a case, further, it is the "whole" method that leads to useless and even injurious associations. Thus, supposing I am learning the following list of words and their meaning:—

Sitte	Custom
Reiz	Stimulus
Aufmerksamkeit	Attention

Now if I read the list rapidly thus—*Sitte* . . . Custom . . . *Reiz* . . . Stimulus . . . *Aufmerksamkeit*, I may tend to set up the useless associations Custom–*Reiz*, and Stimulus –*Aufmerksamkeit*, and this is not only waste of time and energy but it may mislead me into giving *Reiz* as the German for "Custom."

Those who learn lists of vocabularies often find that while they know a word in its appropriate place in the list, they fail to recognise it alone. The supplementary associations with the other words in the list in which it was learned are necessary for its recall. This is especially the case if the list is read through as a whole.

Further, when the material to be learned is a vocabulary, the sectional method has not the disadvantage it has when a poem has to be learned; in passing backwards from Attention to *Aufmerksamkeit*, and then again to Attention and then back to *Aufmerksamkeit*, I am not setting up a useless association as I was in passing from the end of the first section of poem A back to the beginning of the same section. Indeed it is just as useful for me to pass from Attention to *Aufmerksamkeit* as vice versa. Otherwise I am likely to find that while I can give the English for *Aufmerksamkeit* I cannot give the German for Attention.

Yet, in spite of these facts, I have found the "whole" method scarcely less efficient, on the average, than the sectional method even in the learning of vocabularies. The repetition of the same two words several times over tends to become very uninteresting, and leads, with some subjects, to a mechanical kind of attitude, whereas the passing constantly from one word to a new one keeps the attention alert and vigorous. Also some subjects are better able than others to attend to the foreign word and its meaning as one whole, quite separate from the rest, and these subjects do not experience the tendency, of which we have just spoken, to associate the meaning of the first foreign word with the second foreign word (*e.g.* Custom–*Reiz*) even when they read the list straight down.

These and other variations lead to great diversity between individuals. Each student must find out the method which suits him best, observing as far as possible the reasons why that particular method suits him. This applies both to learning vocabularies and to the learning of poetry or connected prose.

As regards poetry and prose we may say, summing up, that for most people the best method of learning a piece of poetry or prose is to read the whole repeatedly, except perhaps that when the piece is almost known specially difficult sections may be selected for additional learning.

The Use of Experiments IX. and X. in Schools.—The application of the results of Experiments IX. and X. in school work will be evident. There is little doubt that children especially are prone to use the sectional method far too much in learning poetry, and possibly the "whole" method too much in learning vocabularies.

If the teacher wishes to apply Experiment IX. to his class he should of course select poetry of a nature more suitable

to children. It will be impossible with young children to make sure that the respective methods are really adhered to at given times. But the experiment may be done orally, the teacher reading out the first poem in sections, repeating each section say four or five times, and reading the second poem in its entirety four or five times, the children writing as much as they can remember after each poem is learned, and again a week later. A practical demonstration of the value of the entire method will be likely to persuade the children to use it more than will the mere recommendation of the teacher.

CHAPTER V.

MENTAL TYPES AS REVEALED BY ASSOCIATIONS AND DESCRIPTIONS.

Experiments XI., XII. and XIII.

These experiments are based upon tests performed by a distinguished French psychologist, the late Professor Binet, upon his two daughters, Armande (age 13 years) and Marguerite (age 14½ years). Binet found that very striking mental differences between the two girls were revealed by these and other tests. Indeed each girl might be said to belong to a fairly marked type. Briefly we may say that Armande was "imaginative" and Marguerite "matter-of fact."[1] We will discuss their results in detail and this will give the reader the clue as to the method of grouping and classifying both his own results and those of any children on whom he may care to repeat the tests.

Experiment XI.

Classification of the Lists of Words Written.—Binet had sixteen lists (of 20 words each) written on different occasions. I have not troubled the student with so many lists, as the main point for him is to grasp the principle involved. But in applying the test to school children it would be well to get as many lists as possible

[1] This is only a rough summary. As we shall see, in some very desirable qualities Marguerite surpassed her sister.

done on different days, to avoid any particular mood or train of thought dominating all the lists.

In experimenting Binet took his daughters separately, and after each list of words was written he questioned them closely as to what exactly they had in mind when each word occurred to them. He then classified the words under the following heads. (Binet himself asserts that the classification makes no pretence at being a scientific one.)

1. *Unexplained words, i.e.* words in reference to which the child could not say what she had in mind when she wrote the word down. She only knew that she thought of the word.

2. Words referring to *objects present* at the time of the experiments, *e.g.* the table on which the child was writing, a picture in the room, the sky visible through the window.

3. Words *connected with the subject herself*, or her personal belongings, *e.g.* her hair or her clothes.

4. *Definite memories.* Here the words were thought of as referring to past experiences which were definitely recalled. These were further divided into old or recent memories, according as they were more or less than three months old.

5. *Abstract and general terms*, including not only abstract terms proper, such as "courage," "goodness," "redness," but also names of classes, such as "house" or "children."

6. *Definite imaginations.* Here some definite object or experience is thought of, but it is not a memory of a past experience. Nor is it merely a general idea such as "houses" or "children": it is the thought of some definite yet imaginary house, or of definite but purely imaginary children. It is sometimes difficult to decide whether a word is to be classified as general or imaginative Doubtful cases may perhaps be counted as ½ to each, unless they are so indefinite as to go under Group 1, Unexplained Words. It should be noted that an imagination-thought may accom-

pany an abstract word. Thus one girl wrote "sadness" but thought of an imaginary person in trouble: this was accordingly put into Group 6.

The following table summarises the results of Binet's experiments.

	Armande.	*Marguerite.*
1. Unexplained words.	Frequent—about one word in three. Also, they were often very uncommon words.	Much rarer than with Armande, only about one word in twenty; and usually commonplace words.
2. Present objects.	Only 30 words out of 320.	Four times as frequent as with Armande.
3. Names of things of personal interest to the subject.	Very rare.	Fairly frequent.
4. Memories.	Old memories predominate.	Recent memories predominate.
5. Abstract and General Terms.	Six times as many as Marguerite.	Only 12.
6. Imaginations.	23.	None.

Let us consider the significance of these differences.

(1) *Unexplained words.*

Armande forgot the exact significance of far more words in her list than did Marguerite. This may have been due to various causes—(*a*) The rapidity of writing, (*b*) Loss of memory, (*c*) A state of distraction, (*d*) A tendency to "verbalism," (*e*) Lack of precision.

Binet noticed that Armande wrote considerably faster than did Marguerite. In order to see whether this was the reason why Armande had so many "unexplained" words he gave the two children several tests of a similar kind, but

on these occasions he asked them to write down the words as fast as they could. In these new tests Marguerite wrote down words as quickly as Armande. Yet the mental type still showed itself: Marguerite now gave about 35 per cent. of unexplained words instead of 5 per cent. previously; Armande now gave 80 per cent. of unexplained words instead of 28 per cent. previously.

It will be seen that the hastening of the speed does lead to a greater number of unexplained words in both cases. Yet the marked difference between the two girls remains even when they work at the same (maximum) speed. Thus speed of writing cannot explain Armande's excess of unexplained words.

Binet found later that Armande had a weaker memory than Marguerite, and this may partly explain the difference under Group 1. But it also possibly indicates a proneness to distraction on the part of Armande, a certain vagueness in her way of thinking, and a tendency to verbalism, *i.e.* merely thinking of a word as such, with no thought of its meaning.

(2) *Present Objects.*

Why does one subject write down in her list so many more names of objects present to the senses at the moment than is the case with another subject? There are at least two possible causes for this. One is a general poverty of ideas. The subject then tends to look about her to find something to write down. Another explanation may be that the subject lives more in externals and less frequently loses mental contact with the material world about her. This seems to have been characteristic of Marguerite, while the attention of Armande was more naturally drawn inwards, though not, be it observed, towards herself particularly.

(3) *Things of Personal Interest* to the subject.

Marguerite had about four times as many words

of this class as Armande had. Binet remarks that this exactly fitted in with his general observations of his daughters, Marguerite being much more attached to her own possessions and regretting their loss or injury more than was the case with Armande.

In this respect it appears that Marguerite was normal while Armande was unusual, for Binet also performed some similar tests upon a number of school children and found that nearly all of them gave in their lists a large number of names of objects belonging to themselves.

(4) *Memories.*

Of recent memories Marguerite had 139, Armande only 30. Of ancient memories Marguerite had 33, Armande 58. It has been suggested that these results also are connected with Marguerite's greater attachment to the visible world, but further analysis of the results would be necessary before this conclusion could be made.

Binet observed that the school children whom he tested included in their lists more memories having reference to school instruction and learning than was the case with his own daughters. Doubtless the fact that he was their father and that the experiments were done in their own home would influence the general set of their minds. The experimenter must always be on the look out for any such influences and the possibilities of suggestion.

Binet noticed that his daughters made no use of recollections of school lessons in ordinary conversations. This fact, and the fact that such recollections did not spontaneously occur in the word lists, indicate a lack of thorough assimilation of the school learning, a fact highly suggestive to the teacher.

(5) *Abstract and General Terms.*

Binet remarks that, while he knew Armande to be imaginative, he was surprised that she had so many abstract

or general terms, thinking for example "house" in general without a thought of any definite house.

He raises the question whether this was due to laziness of thought, a failure to penetrate to the bottom of ideas and to think them clearly. He concludes, however, that it was not so, but that the size of this group in Armande's case was really indicative partly of a tendency to abstraction, and partly of a tendency to verbalism. As we have already seen, Armande was also suspected of verbalism on the ground of her excess of unexplained words.

(6) *Imaginations.*

Binet calls attention to the fact that Armande had more abstractions and yet more imaginations also than Marguerite. Now there is usually thought to be an antithesis between imagination and abstraction. Imagination is characteristic of the poet, the artist, and in a sense possibly of women and children more than of men; while abstraction is characteristic of the theorist, the scientist, and the philosopher, who are interested in unities, generalities, and laws.

But, as Binet remarks, Armande's abstractions were not abstract *reasonings.* They (more especially the general terms) were rather due to lack of definiteness than to a definite act of abstraction. Thus they afford no evidence against the above mentioned popular belief.

Inferences as to Mental Types from the Word Lists.—To sum up, these word lists suggest that the two sisters are of very *different mental types.* Marguerite is interested in the world around her, with ideas comparatively slow in development, yet more definite and precise, and better remembered than those of Armande. She is practical and "objective," attached to the things in her immediate vicinity both as regards place and time.

Armande, on the other hand, is characterised by a rapid flow of ideas, sometimes, however, merely by a flow of words without very definite ideas attached to them (verbalism); these more fleeting ideas are more readily forgotten, and their very wealth is perhaps partly the cause of the lesser extent to which she observes the external world about. Her thoughts are further removed than Marguerite's from the present, both as regards space and time, and with this lesser dependence on and interest in the visible world there is a greater imaginativeness.

The student should now classify his own words and note the extent to which he approximates to one type or the other. If he has done all his lists on the same day he must not be surprised if they are somewhat lacking in variety.

It must not be supposed that all persons belong to one or other of these two types. No doubt Armande and Marguerite were extremes, and most children and adults will be more "mixed." Binet was fortunate as an experimenter in the fact that his daughters differed so widely; otherwise his book would not have been the intensely interesting work that it is.

Experiment XII.

We shall see how the broad distinctions already observed between Marguerite and Armande appear again in Experiments XII. and XIII. Here are some of the sentences completed by the two girls:—

Armande.	*Marguerite.*
"*I am hastening* to write to you, for I have scarcely any longer to live." (Age 13!)	"*I am hastening* to finish my tasks in order to have time to play afterwards." (Doubtless a statement of fact.)

Armande.	*Marguerite.*
"*The house* is on a height whence one sees a precipice, then a town of which one hears feebly the dull and distant noise."	"*The house* is warmed by a good hot-air stove" (a true fact concerning the house in which she was writing).

Similarly one of my students wrote: "*I am now* an old man" (she was a young lady of some twenty summers!), while many wrote, quite truthfully, "*I am now* doing psychological experiments."

The student will not find it difficult to distinguish between the imaginative and the "matter-of-fact" in this test.

Experiment XIII.

Descriptive Types.—The characteristic difference between Armande and Marguerite appeared again in this experiment.

Here are rough translations of the *descriptions of an old halfpenny* by Marguerite and Armande.

Marguerite's description.—"The piece of money I have before me is a sou: it is made of copper, stained through long usage. The back of this piece represents an eagle with wings spread out, for it dates from the Emperor Napoleon III. On the back is written: 'Empire Français, 5 centimes.'

"On the front is the head of Napoleon III. surrounded by the words 'Napoléon Empereur,' and below is the date when the piece was struck, but it is too much effaced and I cannot read it. This piece is not thick—about 2 millimetres."

As will be seen, this is almost purely descriptive, the work simply of a careful observer.

Armande's description.—This begins with some state-

ments of fact, as in Marguerite's case, and then comes an imaginative touch. "How much it would have to relate if it could speak, this sou. Whence has it come? in what lands has it been? One does not even think of it in seeing a humble sou, one does not seek its history, mon Dieu, no! It appears so simple to see, a sou. It is so common. Sous pass unperceived like so many things one is accustomed to see everywhere. . . ."

In this experiment Binet told his children to "describe" the halfpenny, etc. I think it better to use the phrase "write a dozen lines about the halfpenny." This gives greater freedom and the results are not so dependent upon the extent to which the subject literally obeys the instructions.

Among students I have found more approximating to the Marguerite type than to the Armande type as judged by this test. I quote here, however, a striking example of the Armande type as shown in the description of a halfpenny. Of course the subject had not heard before of the characteristic differences of Marguerite and Armande in this respect.

A student's comments upon a halfpenny.—"This is a coin made of copper. On one side is stamped the head of the late king, on the other side the figure of Britannia. If the coin could speak it might tell many a wonderful story. It may have travelled the whole world over, it may have seen many a rich dwelling or many a poor hovel. It may have been dearly prized by a little child or thrown from a rich man's hand to a poor beggar. At present it lies here, the medium of the first experiment of a student."

These description tests have been used for a considerable number of school children and it has been found that, broadly, four types are distinguishable, though of course many are of a "mixed" type.

Four Descriptive Types.

(1) The Describer, who merely mentions all the obvious features of the object which has been given to him.

(2) The Observer or, perhaps better, Interpreter, who is somewhat reflective, drawing inferences perhaps from what he sees, *e.g.* a guess at the coin's date from the evidence of its worn appearance.

(3) The Imaginative, possibly not so accurate or complete in observation. The student's description of a halfpenny given above is a good example.

(4) The Erudite, who tells what he knows about things, making use of general information or of that gained in school; *e.g.* the statement that the halfpenny was made of bronze and that bronze is an alloy of copper and tin, and the giving of the reason why this alloy is used. This kind of answer may indicate an exceptional amount of information, but it may be partly due to an aversion to the careful and patient observation necessary to give one enough material to write about the appearance of the object.

The Use of Experiments XI., XII. and XIII. in School.—Experiments XII. and XIII. would be easy to give to a group of children. For Experiment XI. one may allow all the children together (of a *small* group) to write down their lists of words, but they must be questioned individually afterwards, for the words alone may be misleading, as we have seen. It would be much better, however, to take the children individually, as each should be questioned immediately after writing his list of words.

In forming his judgment as to his own type or that of any children whom he may test, the reader should of course take into account all the evidence gained from Experiments XI., XII. and XIII. The imaginative element, for example, may not appear in all the tests.

Lastly, the reader must guard against the assumption that the Imaginative (Armande) type is necessarily superior to the Marguerite—what we may broadly call the Observer—type. The former is of course superior to the latter in imagination. But the latter is strong in qualities which may be just as admirable and at least as useful, though possibly less interesting, namely—precision of thought and patient and careful observation of certain kinds of objects.

The teacher might find it interesting to apply a few tests like those given in Experiments XI., XII. and XIII., and to compare the results with the essays and compositions of his pupils.[1]

[1] For a full account of Binet's numerous experiments upon his two daughters see his book *L'Etude expérimentale de l'intelligence.*

CHAPTER VI.

ROTE MEMORY.

Experiments XIV., XV. and XVI.

Visual and Auditory Tests.—One fact is made clear by such experiments as those on visual and auditory memory, viz. that it is possible to have a good visual memory (compared with other people) and yet at the same time to have a comparatively poor auditory memory, or vice versa. The present writer, in his experimental classes, has frequently had students at the top of a class, of about twenty-five students, in visual memory tests, but half-way down or even near the bottom in the auditory tests.

This illustrates clearly a fact which modern psychology is demonstrating more and more decidedly, namely, that it is inexact to speak of a person having "a good memory" in general. It is probably very rare that a person has a good memory for everything—not only for visual and auditory impressions, but also for movements, touch, smell, taste, etc. These various "memories" are, we find, to a very great extent independent of one another. Indeed we can go even further and say that a man may have a good memory for some visual impressions but a poor one for other visual impressions. Thus some students who did very badly in the diagram test (Experiment

XVI.) did fairly well in an experiment in which the memory for colours was tested, though this too was a visual test. Here the question of interest enters in. Thus we found a tendency for women to do better than men in the colour test, though not so well as the men, or at least no better, in the diagram test. No doubt this is partly due to the greater interest shown as a rule in colours by women than by men.

Still, on the average, those who are good visualisers and are found to have a specially good memory for any given set of visual impressions will be likely, special interests apart, to have a good visual memory in general. Such individuals may have poor auditory memories, and children of this type will learn their work in school most rapidly and easily when it is presented to them in visual form, while the auditory type will do better with material presented through the spoken word. The psychological justification for combining in a lesson both visual and auditory impressions wherever possible will thus be obvious.

Most children are of a mixed type, and the chief point to be considered in determining the mode of presentation is the material rather than the child. Now, as there are some things which can only be remembered in terms of sound, and others which visual impressions alone can adequately represent (*e.g.* the plan of a town, a picture, the physical characteristics of a country), there is good reason for giving some practice to the children in each of these kinds of memory, visual and auditory, taken individually. By such practice we should probably find that we could thus prevent their losing the power of working with one or the other of these "memories." At the same time it is well for each individual to know where his own particular strength lies, in order that he may

know what means to use when exact memory work is urgently required.

In deciding the question as to his own type, the student may find some help in noticing the kind of mistakes that he makes. Thus persons who rely upon visual impressions tend, in such memory experiments, to confuse letters that look alike, *e.g.* C and G, O and Q. Persons of the auditory type, on the other hand, tend to confuse letters which sound alike, *e.g.* P and B, T and D, M and N.

Use of Experiments XIV., XV. and XVI. in School.—The various tests included under these experiments should not be difficult for the teacher to perform upon his pupils in groups. Of course he must allow more time for very young children to learn the material. By use of the tests he may be able to discover whether there are in his class any children either unusually strong or unusually deficient in either of these kinds of memories. He will probably find the children keenly interested in such tests and anxious to do their best, and he will thus get some light upon the capacities of the children for rote memory work. Thus the real powers of the suspected "slacker" may be revealed, and so may the natural slowness of others who have concealed this weakness by hard work.

The periods at which the "Memories" for different kinds of impressions and ideas are predominant is also a point of interest to the teacher. Thus memory for visual impressions seems to develop more rapidly in early years than does auditory memory.

The teacher may also test the effect of the lapse of time on memory. It has actually been found that children of six can do 50 per cent. better in the reproduction of a poem two days after the poem was learned than immediately after. The same is true, to a lesser extent, for older children. See P. B. Ballard, Obliviscence and Reminiscence, *Brit. Jour. of Psych. Supplements*, II.

CHAPTER VII.

ON THE VALUE OF A MAP.

Experiment XVII.

In this test we have an experiment bearing even more directly upon school work. It is one which I have used to bring home to students the great value of the support of visual impressions in learning and remembering material like that given in this experiment.

Every teacher, one would suppose, knows the value of maps and plans,[1] but an experiment of this nature may bring home their value more vividly to the student and the exact points in which their help is especially useful, if he himself undergoes it, or if he performs the experiment on a class of children.

This experiment is really concerned with substance memory, but it is introduced here in order to illustrate the use of visual memory; it will further be seen that it involves a considerable amount of rote memory work in which visual impressions may be of service.

Most subjects will have realised the value of the map in doing the test, and will find that their performance in

[1] As a matter of fact, however, the present writer was led to devise this experiment after hearing of one teacher who, after a year's training, actually prepared and gave a geography lesson before an Inspector without a single reference to a map, though it was a lesson in which the use of a map would have been extremely serviceable.

Piece A is better than in Piece B, in spite of the fact that their going through Piece A will give them some hints as to the kind of questions to be prepared for in test B. For experiments with classes of students, the teacher can vary the experiment on other occasions by giving the auditory test first when once he has found what length of time is taken by test A. Obviously, if the values of the two methods are to be compared, the same length of time must be spent over each.

If the student doubts the equality of the two pieces as regards difficulty, he can easily make a sketch of Piece B and refrain from using the map for Piece A in a subsequent experiment upon another subject.

In a class of my own students, when Piece A was taken first with the map, and B later without map, the total marks for A were 25 per cent. better than those for B. In another class in which Piece A was taken first without the map and Piece B later with a map, the total marks for the "map piece," B, were over 40 per cent. better than those for A. The difference in these percentages is probably due to the clue given by the first test as to the kind of question to be asked after the second piece. In the case of the first class this advantage favoured the purely oral piece, in the case of the second class it favoured the map piece. The mean between the two, *i.e.* about 33 per cent., probably gives us the true indication as to the superiority of the map method.

CHAPTER VIII.

SUBSTANCE OR RATIONAL MEMORY AND THE CORRELATION BETWEEN ROTE AND RATIONAL MEMORY.

Experiments XVIII. and XIX.

Experiment XVIII. will have shown clearly the enormous difference made by the connection of the meaning of ideas to the possibility of memorising them. The obvious inference of practical value to the teacher is that, wherever possible, the ideas or facts which he wishes to impart in a lesson should form a connected series. One would think this observation unnecessary if one did not know how many teachers seem to rely almost entirely upon forceful repetition rather than upon reasoned connection.

Incidentally it would be noticed that the list of words connected in meaning was more interesting than the other list, and this greater interest of itself would aid the memory.

Experiment XIX.—The main purpose of Experiment XIX. is to demonstrate, when taken in connection with the results of Experiments XIV., XV. and XVI. (rote memory), that it is possibile for an individual to be comparatively good in logical memory and yet weak in rote memory, or vice versa. Thus you may find, for example, that your partner has proved much superior to you in rote

memory tests, but that you are better than he is in the substance memory tests.[1] This possibility, however, of a great difference between the two kinds of memories appears much more clearly if the experiment is done upon a whole class. The present writer has often had students who were at the top or very near the top of a class of twenty to thirty students in the rote memory tests, but near the bottom or actually last in rational memory tests. Of course rote memory is of some value even in the recall of the prose passages, but so great is the help derived from connection of meaning by some individuals that they score better in a rational test even when competing with others who are much their superior in rote memory.

We have observed that a good rote memory may prove valuable in substance or logical memory work. But in one sense the two kinds of memory are opposed and tend to discourage one another. Thus a man with a keen eye for the interconnection of things will look for such connections and tend to rely upon them in his memory work, while impressions which are not connected in meaning will tend to be neglected, partly from lack of interest. This means that his logical memory will develop probably at the expense of his rote memory. This is likely to be the case especially if most of his study is given to subjects which demand primarily reasoning rather than rote memory work. There is, indeed, some evidence to show that even in a series of experiments concentration upon connected prose passages may produce a distaste for rote memory work.

[1] Of course such a difference may be due partly, or even entirely, to the different degree to which the test pieces appeal to the special interests and special knowledge of the individuals tested. It is almost impossible to avoid this complication altogether; one can however lessen its probable influence by multiplying the number of pieces given and selecting a variety of topics.

Conversely, if a person has an unusually good rote memory he may tend to rely upon this to the neglect of more reflective and rational work. Thus the lack of connection between rote and rational memory is not so surprising as it might otherwise appear to be.

The Use of Experiment XIX. in Schools.—It would be a useful thing for a teacher to know as soon as possible the capacity of each of his pupils in "rational" memory of various types of material. It would be worth while at an early stage in his first term with them to give a number of tests of this nature simply with a view to discovering the facts about each child. It is less reliable to depend for his evidence upon the general work of his pupils in any of the school subjects, as the order of proficiency in any such tests is determined by quite a large number of factors, *e.g.* the length of time spent in preparing the work and the previous knowledge of the subject.

Previous training and diligence are the very factors which the teacher wants to rule out in order to discover what the children *can* do in the way of memorising new material if they try and if they completely understand the matter. He should therefore select stories simple in language, but in which there is a rational connection between the successive ideas. The stories should deal with different topics, so that they will not appeal only to certain special interests. It would be wise to give one short passage each day for several days.[1]

[1] Such tests might not unfairly be reckoned as part of a lesson in Composition. But the pupils should not be told this, nor should errors in composition or dictation be corrected until all the tests have been finished. Otherwise a child may hesitate to write down something which he remembers, because he is uncertain as to the correct mode of expression or the spelling.

As before, the statement to the class that he is going to "test their power of memory" will almost certainly secure, for the brief time necessary for the test, the keen attention of the pupils, especially if the teacher announces each day the results of the previous day's test. A comparison of the order of merit of the pupils in logical memory and the order they previously obtained in rote memory will prove interesting and highly instructive.

METHOD OF FINDING THE DEGREE OF CORRELATION BETWEEN TWO ORDERS.[1]

We have already found it interesting and useful to compare two orders of merit, *e.g.* in logical and rote memory, but we have so far been content with a rough comparison, or with the statement that it is possible to be high in one list and low in another, *i.e.* to be very good as regards one kind of memory, compared with other people, but weak in the other.

We often similarly compare the orders of a school class in, say, arithmetic and recitation, and we say, perhaps, that we find that a boy may be good in one subject and poor in another; or we may compare the orders in mathematics and science, and say that most boys who are good in mathematics are likely to be able to do science well.

Now it would obviously be useful if we could make more definite statements of this kind. For example, it would be useful to know to what extent the order of merit in rote memory is likely to resemble the order of merit in logical memory, and whether there is usually more resemblance between the orders for mathematics and science or between

[1] This section may be omitted for the present if the reader desires. But he will find it desirable that he should understand what is meant by correlation and coefficients of correlation when he comes to the chapter on Mental Tests.

the orders for mathematics and Latin. Furthermore, we shall see directly how useful it may prove if we can discover simple mental tests which correlate highly with general intelligence, *i.e.* which give about the same order of merit when applied to a school class as would be given by the teacher in a careful estimate of the general intelligence of his pupils after long acquaintance with them. We are enabled to give such definite estimates of correlation by the method now to be described.[1]

Suppose we want to discover whether there is greater connection between the performances in mathematics and science or between the performances in mathematics and Latin. At a first glance this may be difficult to decide, especially if the lists are long ones. For the sake of simplicity we will here use quite short lists of ten pupils.

The first thing to be done is to arrange the pupils in order of merit in the first pair of subjects, thus :—

	Mathematics.	Latin.	Gains.	Losses.
A	1	1		
B	2	4	.....	2
C	3	3		
D	4	2	2	
E	5	8	.....	3
F	6	7	.....	1
G	7	6	1	
H	8	9	.....	1
I	9	5	4	
J	10	10		
		Totals	7	7

[1] The method described is Spearman's "Foot-rule of Correlations." See *British Journal of Psychology*, Vol. II., p. 89.

Subtract each boy's order in Latin from his order in mathematics. Where the number for Latin is lower than that for mathematics the subtraction will give a plus quantity, and this should be reckoned as a *gain*. Where the number for Latin is greater than that for mathematics we shall have a minus quantity, and this is reckoned as a loss. The total gains and losses are shown above. These should always balance one another.

Obviously the more alike the two orders are the smaller the gains (and losses) will be. By use of a simple formula it is now possible to calculate the extent to which the orders are alike. The figure which indicates this is called the "coefficient of correlation" and is represented by R.

Where two orders are exactly alike the coefficient of correlation, R, = I. This is called "complete correlation."

If R works out as approximately 0 it means that there is no correlation, *i.e.* that there is no greater connection between the orders than may be expected merely on the basis of chance.

If the coefficient works out to a minus quantity it means that there is a tendency for the pupils who are high in one order to be low in the other and vice versa, and this is called "inverse correlation."

The formula referred to is as follows:—

$$\mathrm{R} = 1 - \frac{6 \times (\text{the sum of the gains})}{n^2 - 1},$$

when n = the number of pupils in the class.[1]

In the order given above this works out as follows:—

$$\mathrm{R} = 1 - \frac{6 \times 7}{10^2 - 1} = 1 - \frac{42}{99} = \frac{19}{33},$$

$$i.e.\ \mathrm{R} = 0{\cdot}57.$$

[1] The sum of the gains may be represented by Σg, so that the formula runs $\mathrm{R} = 1 - 6\,\Sigma g/(n^2 - 1)$.

This would indicate a moderately high degree of correlation between mathematics and Latin. In other words, we could say that, as far as one can judge from these orders, there is a distinct tendency for a boy who is good in mathematics to be good in Latin also. We have now to compare this result with the correlation between mathematics and science.

Supposing that we have the following order in mathematics and science :—

	Maths.	Science.
A	1	2
B	2	1
C	3	4
D	4	3
E	5	5
F	6	7
G	7	6
H	8	8
I	9	10
J	10	9

Here it will be found that the gains total 4 and R is approximately 0·76, a higher coefficient of correlation than was found between the orders for mathematics and Latin. This would mean that there is a greater resemblance between the order for mathematics and science than there was between the orders for mathematics and Latin.

It must of course be clearly understood that for any wide generalisation as to such correlation between mathematics and science or mathematics and Latin we must not only have far more pupils but also a considerable number of tests to eliminate variable accidents.[1] Furthermore, we must do the tests in many different schools before we can

[1] See also paragraph on Probable Error below.

state broadly that there is more connection between proficiency in mathematics and science than there is between mathematics and Latin. We can, however, state that in this particular class as taught and examined by this particular teacher such and such is the case.

Naturally we cannot ignore the question of the influence of the teacher. The order in science, for example, when taken by teacher A may vary considerably from the order when taken by teacher B. Indeed two different examinations by the same teacher may give orders varying appreciably one from another.

The Use of Correlation with Mental Tests.—If the memory tests have been done in an experimental class orders of merit should be drawn up for the "rote" and the "logical" tests, and the student should now find the degree of correlation between rote and logical memory. He will probably be surprised at the low coefficient of correlation if the class has carried out the experiment thoroughly, *i.e.* if the rote tests have really been rote tests, from which associations have been entirely or almost entirely excluded, and if the substance or logical tests have been marked in such a way as not to favour unduly the person who has a good rote memory. The present writer in his experimental classes has had correlations as low as 0·2, and even lower, between the orders for rote and logical memory. The correlation may also be found between visual memory and auditory memory.

To Find the Reliability of a Test.—We said just now that two different examinations by the same teacher may give orders varying considerably from one another. This leads us to mention one of the most serviceable uses of the method of finding the correlational coefficient, a

use which is very important in connection with psychological tests.

Suppose I have put my class through a series of tests in visual rote memory, being anxious to know the order of merit of the children in this respect. How am I to know whether the test is a reliable one or not? Does it really indicate the true order of merit of the children in respect to the mental work involved in this test or have accidental variations been at work, *e.g.* was one child unusually careless, another very fatigued, or did the material used favour one child more than another? Now I can get a figure which will indicate to me, and to any others to whom I quote my results, the degree to which this test can be relied upon. The method is as follows.

Having already given one test in visual rote memory and so obtained one order of merit for the class, I proceed to give a similar rote memory test on another day and with new material. This will give me a second order of merit for visual rote memory. Obviously the more alike my two orders are, the more reliable my two tests are proved to be.[1] The extent to which the two orders are alike can be shown by finding the coefficient of correlation between them in the way described above. The number obtained is called the "reliability coefficient," and should ideally be a fraction approximating to one. The experi-

[1] Of course within the limits set by the nature of the test itself and by the number of pupils. Obviously the smaller the number of pupils, the smaller the likelihood of great variations between the two orders.

It is better to get another experimenter to perform the second test, if an equally reliable one can be secured. The correlation of the two orders is then also a check upon any individual peculiarities in the way of presenting the material which may possibly affect the results.

menter should not be *satisfied* with a reliability coefficient much below 0·8 or 0·7, though experts frequently get lower figures. Much of course depends upon the nature of the test itself and upon the number of subjects tested.[1]

It will be seen that such a method of checking the reliability of mental tests or examinations may be applied in various ways. Thus we may find the correlation between (i) the rote memory tests done on a certain school class by one experimenter and (ii) the results of similar tests done on the same children by a different experimenter. This may betray variations of results due to variation of method or to some personal influence. Such a "personal factor" enters not only into psychology tests but into ordinary school examinations. If two teachers were asked to examine the same class in the same subject on two successive days and to compare their orders, there would probably be considerable surprise at the great difference of order due to the personal element of the teacher. Indeed it has been found that two examiners, marking even the same set of examination papers, may give independently orders which do not correlate more than to the extent of about 0·6.

The Use of Correlation in Schools.—The teacher may make use of the method of correlation described to find the reliability coefficient for any psychological tests (*e.g.* visual or auditory rote memory) to which he has submitted his pupils.

The various uses of correlation already mentioned in connection with school subjects may also prove of interest to the teacher. Thus he may test the stability of his own

[1] See note on the "Probable Error" at the end of this chapter for a further means of estimating the extent to which one can rely upon one's results.

examining of his pupils and of their work by finding the correlation between the orders of two similar examinations given at about the same time.

A further question of great interest is the following. What subject gives an order of merit which comes nearest (of all subjects) to the order of the class in "general intelligence"? The teacher must first draw up an order of general intelligence for his class. He must be extremely careful to avoid being influenced by personal likes and dislikes. He knows quite well that the passive obedient boy who gives so little trouble and who agrees so willingly with his teacher is not by any means necessarily more intelligent than the independent rebel, nor has the diligent boy always more of what we ordinarily understand by general intelligence than is possessed by the comparative idler, though no doubt in the long run good general capacity makes a boy take more readily to school work. In particular the teacher must try not to be influenced too much by the performances of the boys in work in which proficiency is largely a question of rote memory.

It would be well, if the class is taken by several masters in different subjects, for each to draw up independently an order in general intelligence, after which the lists can be considered and discussed in council and a final average list agreed upon. Naturally in this the word of a teacher who takes the class in several subjects should have more weight than that of the teacher who only takes one subject and so sees much less of the children.

This final order can then be compared with the order of merit in the various school subjects. By finding the various correlations the teacher will know then to what extent each of the school subjects (as taught in that particular school), Latin, Mathematics, Science, English, Woodwork, etc., correlates with general intelligence. Simi-

larly he may find to what extent any of these subjects correlates with any or all of the other subjects.

We shall find further uses for this method of calculating correlation when we come to discuss mental tests of general intelligence in Chapter XII.

The Calculation of the Probable Error.—It has been assumed in the above discussion that the student will be dealing with groups of subjects at least twenty-five or thirty in number, and also that he will not regard any coefficient of correlation which is much below 0·8 or 0·7 as indicating any decided correlation between the two orders. The larger the number of subjects taking part in the tests and the higher the coefficient of correlation, the less is the correlation discovered likely to be due to mere chance.

The figure known as the "probable error" gives us an estimate of the extent to which mere chance is likely to cause a correlation. If the above formula (Spearman's "Foot-rule") is used, the probable error is equivalent to $\frac{0{\cdot}43}{\sqrt{n}}$, where n = the number of persons on whom the tests are performed. If the number of persons is much below thirty the probable error should certainly be calculated. Any coefficient of correlation should be about five times the probable error if it is to be regarded as a proof of a real correlation between the two orders.

For a more elaborate and, according to some mathematicians, more accurate method of calculating correlation and the probable error see C. S. Myers, *Text-book of Experimental Psychology*, p. 123, or W. Brown, *Essentials of Mental Measurement*.

CHAPTER IX.

THE IMPROVEMENT OF THE MEMORY AND THE TRANSFER OF MEMORY IMPROVEMENT.

Experiment XX.

Interpretation of Results.—When all the results of Experiment XX. are before him the student should carefully compare the score for Test A, taken before the practice period, with the score for Test B, taken after the practice period. Suppose that poetry has been learned during the practice period, has this resulted in an improvement in the capacity for learning poetry as shown by Test B compared with Test A? If so, does the control group show any improvement on the poetry test of Test B?

Further, has the exercise of the memory with poetry resulted in any improvement in the other memory tests, with letters and nonsense syllables, *i.e.* is there a *general* improvement of the memory?

In the chapter upon rote memory we saw that it was undesirable to speak of memory in general, and that we ought rather to regard memory as an inclusive term covering various functions, such as visual memory, auditory memory, etc.

Recent researches also suggest that there is no such thing as general memory improvement producible by practising the memory with one kind of material.

If the results of a whole class in Experiment XX. are considered, one fact at least is likely to appear, namely, that there is little or no general improvement in all the kinds of memory tests as the result of practice in poetry or vocabularies,—at least no greater improvement than the results given by the control group may show to be attributable to the practice gained in Test A itself, or to the lesser difficulty of Test B.

It used to be thought that the study of, say, Latin "strengthened the memory," so that a boy could remember history or poetry better for having ground away at Latin verbs. We have now good reason to believe that practice of the memory with any given material will effect relatively little improvement in the memory for a second kind of material, except in so far as the two materials resemble one another. This statement, however, only seems to be partially true and we must modify it somewhat.

Mode of Transference of Memory Improvement.—Let the student examine his own or the class results in Experiment XX. He may very likely find that practice in poetry appears to have resulted in an improvement in the power of memorising poetry. One group of a class of my own improved in this respect 15 per cent., though the control group showed no such improvement. But is this necessarily due merely to the fact that we are dealing with poetical ideas? Almost certainly not, for it has been found that practice in poetry may actually improve the power of learning and remembering even nonsense syllables, if these are rhythmically arranged. Here the only resemblance seems to be the common element of rhythm. Apparently the sensibility to the influence of rhythm, or the facility in making use of it in learning work, is increased by such practice with poetry, more especially in

the young, where there is ample capacity for such development.[1]

This greater sensibility, or facility, appears to aid the assimilation or the retention of the rhythmic material. If the student examines his answers to the rhythmic nonsense syllables test, he may notice that sometimes he has paired a nonsense syllable with its wrong partner, but that he has at least given it its correct position as regards the beat and rhythm. This often happens, and it shows how strong may be the association between a syllable and its appropriate stress or beat. In a class of my own, the group which had practised with vocabularies showed an improvement of 20 per cent. in the learning of pairs of nonsense syllables, though the control group scarcely showed any improvement in the same tests. Possibly here, too, the facility which had been gained in using rhythm in the learning of vocabularies proved useful in the subsequent learning of nonsense syllables.

In a somewhat similar way it seems possible for the capacity for visualisation (or at least for the habit of using it in learning) to be increased through practice in learning, say, nonsense syllables or vocabularies. This improvement in visualisation may then reveal itself in improvement of the memory of material of quite a different nature, providing that visualising can be made use of here also. Thus if the student has learned to make more use of his visual memory in the course of learning vocabularies, he may find that he improves in the visual letter test in Test B without doing so in the auditory letter and figure test. He should, as always, carefully compare his results with his introspective remarks made at all stages of the experiment. Such

[1] Many adults have no doubt reached a stage in which the facility in such use of rhythm can be no further developed.

remarks may be able to explain apparent anomalies. Thus those members of the class who visualised in the auditory test may find that they improve even in this test as the result of practice in visualisation.

We see then that there may be a kind of transfer of memory improvement through practice in one kind of material to the capacity for learning another kind, through such common functions as visualisation or rhythmisation. But it is found that slight changes in method may easily disturb this transfer through a common function. And there is some evidence that, in any case, transferred improvement is not of a very permanent nature. At any rate such improvement is not enough to justify us in giving a boy X to learn in order to improve his memory for Y, as long as we can give him Y itself.

Great improvement may of course take place where the material I learn now is itself a help in learning and remembering other material. For example, if my mind has been well stored with historical facts I shall learn and remember new historical facts more easily if these new facts are connected with and can be linked on to the old ones.

The whole question of the transference of memory improvement is a very complex and difficult one, and in this brief account we have had to pass over many problems. Among other things we have ignored the distinction between (1) improvement of the power of learning and (2) improvement in the power of retaining, *i.e.* in memory proper. The distinction is interesting theoretically, but from the educational point of view it is not so important as it may appear. For even if all improvement is really improvement in the power to learn, this means that a given amount of material is really learned in a shorter time, and so some time can be spared subsequently for revision; consequently,

with a double learning the work will finally be remembered better.

Finally it must be remembered that experiments on the transference of memory improvement have only extended over a relatively short period. It is quite likely that there would be more "transference" as the result of the prolonged memory work of ordinary school work.

References for further reading on this important topic will be found in the bibliography at the end of the book. In the foregoing chapter I am especially indebted to W. G. Sleight's excellent article in the *British Journal of Psychology*, Vol. IV. For a theoretical discussion of the question of the improvement of the memory see James, *Principles of Psychology*, Vol. I., p. 667, and Stout, *Manual of Psychology*, p. 582.

CHAPTER X.

THE ACQUISITION OF SKILL. THE METHOD OF TRIAL AND ERROR.[1]

Experiments XXI., XXII. and XXIII.

The Method of Trial and Error.—The experiment in mirror drawing illustrates what is perhaps the most fundamental and elementary method of learning, viz. learning by trial and error, or, as it might better be called, by trial and elimination of error.

Suppose I have a safe, with a combination lock of which I know the key to be CXB. Knowing this I can at once set the letters in their right position and open the safe. Here I am applying knowledge of a fact in order to do something.

My procedure is fundamentally different if I try to learn such a game as golf. No doubt to some extent I can make use of knowledge, *e.g.* advice and information from an instructor. But to a large extent any progress I make in the game is due to a much less deliberate and less conscious process. I hit at a ball and miss it. I take another aim, and this time my procedure is modified. Certain muscular contractions which led to my previous error tend to be avoided, and this time I succeed in making a hit, though a bad one. Yet I may be quite

[1] In connection with this chapter the student may read Stout, *Manual of Psychology*, pp. 375-384.

unable to say exactly what modifications took place in the second stroke, and at the third stroke I may miss as badly again as I did at the first stroke. Only very gradually are the wrong movements eliminated and the right ones stamped in. Probably the thrill of pleasure experienced when we feel that we have done the right thing helps to stamp in the tendency towards the performance of that right action, so that on another occasion it is more likely to recur than it was previously.

In learning golf thus, I am using the method of trial and error, and this method is constantly used by children in developing motor habits, not only in the very early stages, *e.g.* in such actions as grasping, walking, throwing a ball, etc., but also in learning to draw and write, or to play a musical instrument.

Value of the Mirror-drawing Test.—It is chiefly in order to bring home to the student the nature and the extreme difficulty of this method of trial and error that the mirror experiment is given. The child in learning to write has to coordinate certain definite hand movements with sight. Similarly in the mirror experiment the student has to establish new coordinations between hand movement and the visual impressions reversed by the mirror. The gradual and irregular way in which such coordinations are established will be readily seen from the curves of times and of errors, especially the latter. As we have already indicated, the method of trial and error is especially characterised by this variability. Thus to-morrow I may be worse at golf than I am to-day, and similarly the child may be worse at writing, but he does not therefore deserve a scolding for carelessness. Only very gradually can the wrong movements be eliminated and the right coordinations set up.

Below are given the actual curves of one subject for time and errors in Experiment XXI. Note especially the great irregularity of the error curve. Sometimes subjects improve more rapidly as regards errors, but do not reduce

MIRROR-DRAWING CURVE.

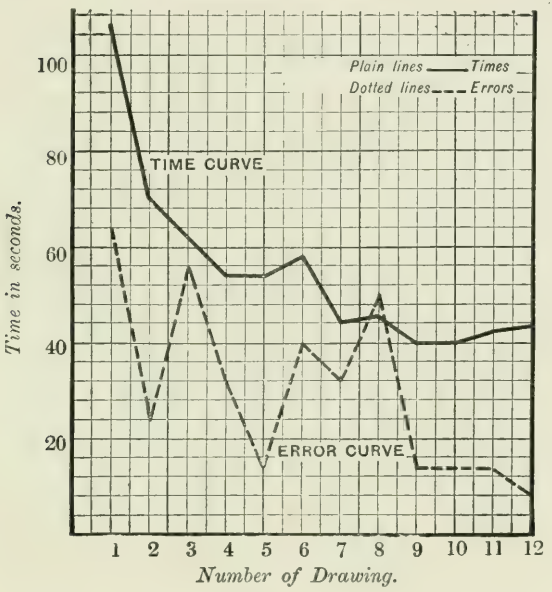


Fig. 7.

their time so much. Others reduce their time more rapidly, but make very little reduction in the matter of errors.

It has been found that, in the course of learning motor habits, *e.g.* in learning typewriting, the curve of progress here and there shows a plateau, where for the time it

appears that no progress is being made. Possibly it indicates the occurrence of a rest period, which, as it were, the mind unconsciously takes when it has been hard-pressed.

The experiment will provide for the teacher a concrete example of the difficulties that children have to face in developing the proper coordination of muscles for whatever purpose this may be necessary, and of the gradual and irregular progress which is essentially characteristic of this method of learning. The work of the child in learning to write or draw will at least be no less difficult than the mirror drawing is to the student, for the latter simply has to learn to reverse the directions of all his usual movements. The continuation of a movement in a straight line, once the student has started in the right direction, is already partly provided for by previously acquired motor habits. Furthermore, the adult sometimes quickly works out the principle that he must move his hand away from the mirror when he wants his pencil to move towards him. Of course in so far as such a principle is applied the method is no longer purely a method of trial and error, and that is why the student is advised to avoid reflecting too much upon his movements as he tries to trace the figure.

CHAPTER XI.

MENTAL FATIGUE.

Experiments XXIV. and XXV.

Discussion of Results of Experiment XXIV.—The subject of fatigue is a highly complex one and has received an amount of attention from experimental psychologists proportionate to its importance. We must here confine ourselves to a brief and simple discussion bearing directly upon the experiments given.

The student should first study the nature of the curve of work in Experiment XXIV. in connection with his own introspective remarks. It is frequently found that the curve is affected by the following factors.

Factors Affecting the Work Curve.—In the first period of work there is often a good performance due to the *novelty* of the experiment. This may be followed by a drop, but the curve soon rises owing partly to *practice*, and partly to the fact that the subject "warms" to his work. This is called *incitement*. If the work is sufficiently prolonged, *fatigue* eventually sets in, showing itself as a rule chiefly in a larger number of errors rather than in a decreased amount of work. There are frequently, of course, fluctuations at this period. Some psychologists believe that the feeling of fatigue causes the subject to rest somewhat for a time, so that he recuperates; and thus

shortly after a drop owing to fatigue the curve may suddenly rise again as a result of such recuperation.

Finally, if the work is sufficiently prolonged, there is a marked deterioration, the quantity of work done dropping, as well as the number of errors increasing. If at the beginning of the last period a warning is given to the subject that he has now reached the last section of his work a final spurt at the end may be observed, though an increase in the amount of work done in this last period may be more than counterbalanced by increased inaccuracy.

We have here described what may be called an ideal curve, but some of these variations may not appear in any given curve. Throughout the book we have emphasised the enormous importance for the experimental psychologist of the fact of individual variations, and this fact is very evident in the case of fatigue.

Analysis of a Fatigue Curve.—Below is given an actual curve of a subject who worked at the crossing out of four letters in continuous prose for twenty-two minutes. Let us study the given curve in detail. In the first place there is in this case no specially good performance in the first period of two minutes. Practice effects, however, are very quickly shown, culminating in the maximum score of 143 at eight minutes, though this improvement is somewhat discounted by the considerable increase of errors during the same period. There follows then a marked drop in the amount of work (see below), though the errors slightly increase. Then there is a suggestion of the rhythmic return of more efficient work as the work curve rises slightly and the errors decrease. Then comes a second drop in the work done, and the signal given at the twentieth minute that the last period had arrived only

succeeded in arresting this drop in the amount of work done at the expense of an enormous increase in the number of errors.

FATIGUE CURVE.

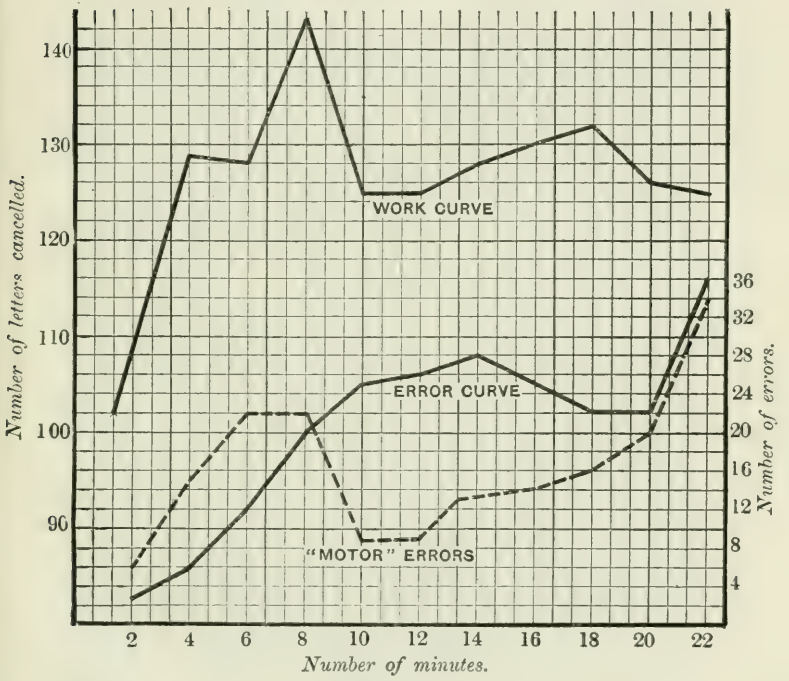


Fig. 8.

We still have to consider the *motor errors*, i.e. the cases in which the subject failed in her attempt to cross out the letter properly, putting the mark beside the letter instead of through it. These errors are indicated by the motor

curve above. From a consideration of this motor error curve we may conclude that the great drop in the work curve after the maximum of 143 is reached is partly due to the student adopting an attitude of greater carefulness in manipulating her pencil, for here the motor errors decrease.

The fact that fatigue was present at the end of the test is emphasised by the great rise in the motor error curve co-incident with the rise in the error curve proper. With the warning that the last period was reached the subject attempted more rapid work, but succeeded only in increasing her number of errors of both kinds, while the amount of work showed no increase. As stated before, neither kind of error (motor error or omission) is subtracted from the total number of letters crossed out as shown in the work curve.

The subject whose curve is shown above was unusually quick in showing the effects of fatigue. There seem, however, to be some subjects who do not show fatigue either by a lessening amount of work done or by an increasing number of errors, even in as long a period as two hours spent in arithmetical calculations. There are doubtless marked individual variations in the extent to which a subject "works himself out." Some work steadily at a pace which is not really their highest possible, though they may not be conscious of this. This fact is shown sometimes by the sudden increase of which they are capable when they hear that the last period is reached. Others, on the other hand, work up to their full capacity all the time, and an effort to spurt only shows itself, as we have seen above, in a greater number of errors.[1]

[1] As far as my own observations go an increase in the amount of work due to a spurt at the end is found more frequently among

Fatigue and Boredom.—Those who find that they can do much better with a spurt may have imagined that they were really fatigued: indeed they may have felt very tired. Probably they were suffering from boredom more than from anything else. Indeed it is often difficult to distinguish between fatigue and boredom. All students know how, when they are feeling tired with their work, if a point of special interest arises, all thoughts of fatigue may be forgotten and work may go on quite vigorously again. In such cases we are probably only bored, rather than fatigued in the special sense in which experimental psychologists are now using the word, namely as indicating *a reduced capacity for work.*

In this sense fatigue must be distinguished not only from boredom but from *the feeling of tiredness.* Normally the feeling of tiredness acts as a safeguard against excessive work, but it seems possible for some subjects to feel "tired" when there is no real fatigue in the special sense used above. On the other hand, in some cases a state of serious fatigue seems to be reached before adequate warnings are given by the feeling of tiredness.

The testimony of a person as to his own state of fatigue is thus seen to be not always reliable. The student should carefully compare his own introspective remarks as to his feelings of fatigue with the objective record of the work done. It will be found also that one's impressions as to the amount of work done are often untrustworthy. Thus one subject wrote that he seemed to be going much more slowly than in a previous test, whereas he was really going faster.

men than among women. Whether this is due to the slower onset of fatigue with men, or to the fact that they do not "work themselves out" as conscientiously as the women do, I leave the reader to judge.

Mechanisation.—One further point the student should observe, namely the tendency towards "mechanisation." As we have already seen in Experiment VII., the simpler the work, the more readily does it tend to become mechanical. This is in itself a means of relieving higher mental processes from some of their work, and so of lessening their fatigue.[1] The writer finds that in the case of many subjects, himself included, the onset of fatigue seems to show itself partly in the occasional failure of such mechanisation of mental work and in the recurring necessity for very deliberate attention to the method of working.

The Effect of a Pause.—As an interesting variation of the method of Experiment XXIV. the introduction of a short pause in the middle of the work period was suggested. This naturally delays the onset of fatigue. But if the pause is very short, more is lost through the loss of incitement and the necessity of "warming up" to the work again than is gained in any other way. On the other hand, if the interval is indefinitely prolonged, something is lost through the partial disappearance of the improvement due to practice. The ideal pause, which gives the maximum amount of work, naturally varies with the individual and according to the nature of the work and the length of the total work period.

The following is an interesting curve showing the work done by a student with the multiplication test given in Test B, Experiment XXIV. Half-an-hour's work at the test was followed by the usual college interval of ten minutes, after which a further period of sixteen minutes was spent at the test.

[1] In some mental tests it would seem that the rapidity with which work can be mechanised is some indication of the intelligence of the worker.

From the curve it will be seen that practice effects are very obvious in the first quarter-hour's work, but little

FATIGUE CURVE SHOWING EFFECT OF INTERVAL.

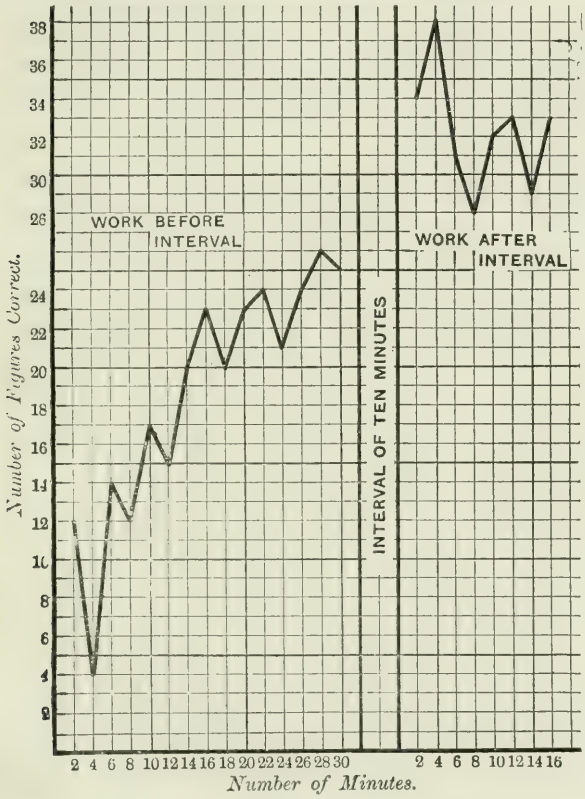


Fig. 9.

further advance is made in the second quarter-hour. Yet much better work is done after the interval, though there

has been no further practice. The explanation must be that fatigue was overcoming any further tendency for the curve to rise through practice effects in the second quarter-hour. The interval proved to be of serviceable length, largely removing the effects of fatigue and allowing the effects of practice to show themselves more completely. (The number of errors made by the subject was inappreciable.)

Discussion of the Results of Experiment XXV.— We turn now to Experiment XXV., in which the fatigue tests are applied at different times of the day or after varying kinds of work. Here we have a different principle of experiment involved. Previously, in Experiment XXIV., we were estimating fatigue due to arithmetical work by changes in the amount and accuracy of the work itself. Now we are concerned with the fatigue due, say, to an hour's physical exercise, and we are seeking to detect its presence by introducing a test which involves a different kind of work. Such are called *interpolation tests.*

This method calls for comment. Interpolation tests involve the assumption that the fatigue produced, say, by Latin or gymnastics will result in a lessened capacity for doing the arithmetic of the fatigue test. Now it is well known that after a change of work we often feel a renewal of vigour, and some writers question whether there is any "transfer" of fatigue. In some cases indeed a period of mental work actually seems to increase the amount of physical work done in the succeeding work test. On the other hand it is evident that we cannot continue indefinitely the renewal of mental vigour by the mere changing of our work, for a kind of "general" fatigue sets in. A discussion of the solution to the apparent contradiction here would carry us too far into the physiology of fatigue. For

practical purposes we may regard it as a question of degree. Each special kind of work causes fatigue particularly for that special work, and if sufficiently prolonged it also contributes to general fatigue.

The student will thus be prepared for very varying results from his interpolation tests according to the nature of the work which has preceded them. Normally one might expect that the greater the change of work, the less will the fatigue due to the previous work be shown in the fatigue test. But this rule is liable to at least one marked exception. One of the most valuable results of fatigue tests has been to show that vigorous physical work is not always a good preparation for immediately subsequent mental work, although the change is so great. Some writers indeed go so far as to regard drill and gymnastics as the most fatiguing of all school work.[1]

The Use of Fatigue Tests in Schools.—It should not be difficult for the teacher to apply the methods of experiment illustrated in the tests on fatigue, in the course of ordinary school work, should he so desire. He may quite well use a series of very simple arithmetical calculations, well within the capacity of the children of the class to be tested. As such are frequently used in school for

[1] The writer is very conscious that this chapter is far from being a complete discussion of the problem of mental fatigue, which is of course complicated by the interference of bodily fatigue, the necessity for recurring intervals for the nourishment of the bodily organism, etc. For a further discussion the student is referred to C. S. Myers, *Text-book of Experimental Psychology*, Chapter XIV.; Claparède, *Experimental Pedagogy*, Chapter V.; Dumville, *Child Mind*, Chapter IX.; Rusk, *Experimental Education*, Chapter XIII.; Offner, *Mental Fatigue*, translated by Whipple; and to the articles mentioned in the Bibliography.

practice in accuracy, he need not feel that he is wasting time from the point of view of the ordinary school work.

If the amount and accuracy of work done is to be the criterion of fatigue the work selected should conform to two conditions. In the first place, as already stated, it must be well within the power of the children to perform fairly accurately when at their best. Secondly, the work must be throughout of equal difficulty, as far as this is possible.

The teacher should be able to provide long lists of short sums that will conform sufficiently to this condition. He may speak of the test as a kind of competition to see which pupils can work most quickly. Such tests might be applied for any of the purposes already referred to in the experiments for adults.

The Method of Equal Groups.—In order to allow for the effect of practice the following plan may be used. After three or four preliminary tests with the given material, the class may be divided into two equally efficient groups, A and B, upon the basis of their performances in these preliminary tests.[1] Group A may now take a second series of three or four tests at, say, some time in the morning session for several days. Meanwhile group B may do the same test at the end of the afternoon session of the same days. Or group A may do the second series of tests after, say, physical exercises, and group B after sedentary work. As groups A and B did equally well in the first series of tests, any marked differences of results between the results of group A's second series of tests and group B's second series of tests may probably be ascribed to the fact that they were either done at different times of the day or after subjects producing different degrees of fatigue, or at least of what we may call "fatigue for arithmetic."

[1] See p. 48 for a method of division into groups of equal efficiency.

In a similar way a teacher may make use of several of the tests already given in this book, more especially rote memory tests, or Experiment VII. on the division of attention.

Fatigue and the School Time-table.—The teacher may also perform experiments to find the degree to which different kinds of work suffer through being done at the slacker periods of the day. This is obviously an important question with a view to the best placing of subjects in the time-table.[1] Much research remains to be done in reference to this problem, though some important results have already been obtained. There is, for example, some evidence that the fatigue experienced by many elementary school children towards the close of an afternoon's session unfits them for arithmetical problem work to a greater extent than it does for rote memory work. To deal with such a problem we do not of course need to interpolate special fatigue tests, but to compare the work done in arithmetic by a group of pupils during morning hours with the work done by the same group, or, better, with a group of equal capacity, working in the afternoon, and then to compare similarly the work done in the learning of poetry or of tables by two equal groups, one working in the morning and the other in the afternoon.

This division into groups may prove an interference with the school routine, but as the test work is to be done in silence, the second group of the class can also be doing

[1] Where different subjects are taught by different teachers the possible influence of the teachers upon the development of fatigue must be kept in mind. Thus a class may be more fatigued after a lesson in arithmetic with teacher A than after a lesson on exactly the same topic with teacher B. This question of the influence of the teacher upon fatigue may itself be made a subject of experiment.

some silent work, such as the learning of poetry, while the first group are doing the arithmetic test, the first group learning the poetry when the second group are doing the arithmetic test. Thus the whole class will be occupied with some useful work.

Dictation as a Fatigue Test.—The difficulties due to the complicating effects of practice can be largely avoided if such a subject as Dictation is chosen as a fatigue test, only those errors being reckoned which cannot be attributed to real ignorance, but rather to what the teacher would call usually "carelessness." The dictation must be given slowly, so that there is no need for any child to hurry. Under these conditions the dictation test has yielded striking results. Thus the classes tested before school and after school in the afternoon gave the following number of such "slips" (per 100 letters and per 100 pupils).

Slips in Dictation.

	1st class	2nd class	3rd class
Before school	123	121	72
After school	156	145	102

The table shows an average increase in the number of errors of about 30 per cent. due to afternoon's work.

CHAPTER XII.

GENERAL INTELLIGENCE TESTS.

Experiments XXVI. and XXVII.

Completion Test.—The following are the passages, printed in full, of which portions were used for completion tests in Experiment XXVI.

Piece A.

"About three-fourths of the whole population of England belong to the wage-earning classes; and at all events when they are well fed, properly housed and educated, they have their fair share of that nervous energy which is the raw material of business ability. Without going out of their way they are all consciously or unconsciously competitors for posts of business command. The ordinary workman, if he shows ability, generally becomes a foreman; from that he may rise to be a manager, and to be taken into partnership with his employer. Or, having saved a little of his own, he may start one of those small shops which still can hold their own in a working man's quarter, stock it chiefly on credit, and let his wife attend to it by day, while he gives his evenings to it. In these or in other ways he may increase his capital till he can start a small workshop or factory. Once having made

a good beginning, he will find the banks eager to give him generous credit."[1]

PIECE B.

One day the eagle went with the other birds to see which could fly the highest. They agreed that he who could fly the highest should be called the strongest bird. All started at the same time and flew away among the clouds. One by one they grew weary and returned, but the eagle flew upward and upward until he was a mere speck in the heavens. When he came back the others were waiting for him; and when he touched the ground a linnet flew off his back, where he had been hidden, and said that he himself was the strongest bird. "I am stronger than the eagle," said the linnet, "for not only did I fly as high, but when he began his downward flight, I left my hiding-place and flew up a little higher." After this boastful speech the others shook their heads and called a council to decide the matter. After a long debate they decided that the eagle was the strongest bird, for not only did he fly so high, but he carried the linnet as well. To this day his plumes are worn the emblems of strength and courage.

The Possibility of Estimating General Intelligence by Psychological Tests.—Experiments XXVI. and XXVII. have been given as illustrations of the kind of tests which psychologists have recently devised as means of testing general intelligence. A book of this kind would hardly have been complete without some reference to work of this nature, which has received a considerable amount of attention of late. For though the

[1] From Alfred Marshall, *Economics of Industry*.

estimation of general intelligence by means of comparatively simple psychological tests is still a question of dispute, some eminent psychologists speak with confidence of the future of such tests [1]. We will here briefly consider further their nature, their possible uses, and the conditions to which they must conform. It should be understood at the outset that not even the most sanguine psychologist would claim that any *one* test can give a satisfactory estimate of the order of intelligence of a class of children. All would agree that a group of tests would be necessary, probably at least half-a-dozen.

We have already given several examples of tests which have been found to give high correlations with general intelligence as estimated by teachers, viz. mirror drawing, "opposites" (restricted association) test, completion test, apprehension of numbers.

Other tests which have given very high correlations with general intelligence are the following: (1) Completion of Analogies, *e.g.* storm : calm : : war : ——. (2) Formation of sentences to include given words, *e.g.* moon . . . circle. (3) Judging whether given syllogisms are valid or not. These and the other tests mentioned have given correlations with "estimated intelligence" varying from 0·5 to 0·8 and even higher.

The question naturally arises, how is it that the order of merit in the performance of such tests resembles so closely the order drawn up by teachers upon the basis of their estimate of the general intelligence of the children? How is it also that tests so dissimilar, apparently, as the completion test, mirror drawing test, and the apprehension of numbers test correlate highly with one another?

The presumption is that in all such tests children do

[1] Cf. W. McDougall, *Psychology* (Home University Library), p. 190 f.

well in proportion to their possession of some *common factor* which plays a predominant part in determining general intelligence, possibly, for example, voluntary attention, or perhaps a kind of "mental energy."

If such a presumption could be soundly established mental tests would, without doubt, provide a very useful means of estimating the mental capacity of children. Let us for a moment compare the possible values of mental tests with those of present day examinations.

Mental Tests compared with Examinations.—(i) *Mental tests estimate "native" capacity rather than acquired knowledge.* Of course it is not claimed that experience and training have no effect upon the capacity to do such tests, but rather that, in so far as such is the case, all children of the same age have had about the same amount of experience. These mental tests can therefore be fairly applied to children who have had very different kinds of school training. The most evident difference between mental tests and examinations lies in the fact that special preparation in the subject of the examination is so important a factor in determining success. The length of time the child has studied the subject, and the quality of the teaching which he has had, help to determine the result of an examination, so that this result does not depend merely upon his own congenital capacity.

The particular kind of education the child has had does not, however, affect the results of such a test as the apprehension of numbers or mirror drawing. Thus we could apply them quite fairly to children whose training had been very different. Indeed they have actually been used to compare the general intelligence of children at a high-class Preparatory school with that of children at an Elementary school. Opinion seems to be very widely

divergent as to whether two such groups of children would differ greatly as regards *native* intelligence.

Obviously it would be unfair to attempt to decide this by means of examinations in school subjects, for the children of a Preparatory school will have had much better training in certain subjects though the Elementary school children may have concentrated more thoroughly upon others. We should be at a loss to know whether we should attribute a better performance in, say, arithmetic on the part of one of these groups of children to a more efficient or prolonged training in the subject or to superior natural capacity. But such tests as mirror drawing, apprehension of numbers, and several other simple tests do not suffer from such limitations. The school training of the Preparatory school children will not give them any advantage in such tests.

On the other hand, from another point of view, examinations are superior to simple mental tests. This is due to the very fact that examinations are means of estimating not merely native ability but also previous training and application. Thus they are tests of the amount of good work done, and even of the presence or absence of some valuable moral qualities which have little or nothing to do with success in psychological tests.

(ii) *Mental tests can be kept more constant in difficulty and can be more exactly marked than is the case with examinations.* Thus they can be more easily standardised, and the results given by children in different schools and even in different countries can be compared.

All who have had any experience in examining know how difficult it is to set two examination papers of exactly equal difficulty. Further, it is often difficult to maintain the same standard throughout in marking the answers of the same examination paper. When different examiners

set and mark different papers in different schools, or in the same school at different times, still greater divergence of standards is likely to result. With many mental tests, however, a more constant standard can be maintained and exact marking is easier. Thus one experimenter can apply certain tests to children in England and another experimenter can apply the same tests, in the same manner, allowing the same length of time, to children in America, and the results may be fairly compared.

Further, it may be possible, by applying simple tests to a child on his entering school, to prophesy with greater certainty than we can at present concerning the likelihood of his future development.

Mental tests may even eventually provide us with a means of estimating mental capacity, which will be fairly constant from year to year and from generation to generation. Possibly we may look forward to a time when every child will be subjected to simple mental tests at various periods of his school life and when these records will be kept, so that eventually there may be an enormous amount of material, not now available, for comparing the general intelligence (in so far as it can be estimated by such tests) of several generations as well as of different countries.

All this may no doubt seem very much in the air, and it must be admitted that many of the mental tests so far used are not exempt from possible criticism, as we shall shortly see, yet some work of no little value has already been done with mental tests.

Examples of the Application of Mental Tests.— They have, for example, been applied with success in the differentiation of backward and normal children.[1] They

[1] See A. R. Abelson, "The Measurement of Mental Ability of Backward Children," *British Journal of Psychology*, Vol. IV.

have been used further to estimate the comparative intelligence of the sexes,[1] a problem obviously difficult of solution by ordinary examination methods owing to differences of previous training; for even when boys and girls are educated in the same school, the influence of home, of friends, and of the general traditions of the sexes, and the divergence of future purposes and aims, greatly affect the attitude of boys and girls to the respective school subjects. Further, success in school work depends not merely upon intellectual capacity, but also upon such moral qualities as conscientiousness.

Lastly, mental tests have been applied to the problem of the hereditary transmission of intelligence. In the very interesting experiments upon Preparatory and Elementary school children already mentioned, it was found that, in all the tests which correlated with general intelligence, the Preparatory school boys were superior to the boys of the Elementary school. The only two tests in which the Elementary school boys were equal or superior to the others were tests which gave *negative* correlations with intelligence, *i.e.* in which duller boys of each school did better than the more intelligent boys of the same school.[2]

Teachers may be interested to learn that, on the basis of the tests in the Preparatory school, the investigator surmised that one boy was not placed so high in the school as his intelligence seemed to entitle him to be. The headmaster accordingly promoted this boy as an experiment, and reported, six months later, that the boy had amply justified his promotion.

[1] See C. Burt and R. C. Moore, "The Mental Differences between the Sexes," *Journal of Experimental Pedagogy*, Vol. I.

[2] See C. Burt, "Experimental Tests of General Intelligence," *British Journal of Psychology*, Vol. III.

Criticism of Mental Tests.—I have thought it well to give some account of these general intelligence tests because of the intense interest of the subject and because of the attention they are attracting at present in the psychological and educational world. At the same time it is well to recognise some possible sources of weakness in the tests.

Some critics are not completely satisfied that the common factor, which is apparently involved in some of these mental tests, is really intelligence, or even a mental function which constitutes an important element in general intelligence. It has been suggested, for example, that such tests correlate with one another because of the dependence of all of them upon the attitude adopted by the boy towards such tests, for example the degree of conscientiousness and of thoroughness with which he tries to do what the experimenter tells him. But even if this explained the intercorrelation of the tests among themselves, it hardly seems to explain their high correlation with general intelligence as estimated by the teacher, unless we suppose that the same kind of conscientiousness was also the basis of the teacher's estimate.

When we consider the tests themselves other objections are apt to suggest themselves. It seems possible that experience, even of a specialised kind, may have considerable influence in determining success in some tests. Thus literary training and the extent of vocabulary doubtless help to determine the child's success in the Completion test. It must, however, be admitted that, as regards a number of the tests, the only kind of experience which is of value is of such a broad general nature as to be fairly common to all children of a given age.

A more serious criticism of the tests, as tests of general intelligence, seems to me to lie in the fact that they give no scope for the application of those special interests which

are so important in determining the value and extent of mental work.[1]

In ordinary life it is sometimes the case that intensity of interest compensates, partially at least, for inferiority of mental capacity of a certain kind at the start. As a rule, no doubt, lack of capacity tends to deaden interest; but a keen interest may at least quicken and develop capacity which would otherwise have lain dormant. The mental tests we have in mind fail to give any estimate of the presence or absence of such great dominating interests. It is not surprising then that they do not seem to afford satisfactory intelligence tests for adults.

On the other hand, it may be urged that an important element of general intelligence is the very capacity to apply oneself to comparatively uninteresting things, or to adapt oneself to, and find an interest in, novel tasks, and that for such capacities the mental tests give considerable scope.

A further objection may possibly be raised on the grounds that, in mental tests, the work almost always has to be done at high speed and the mind that works slowly but thoroughly may seem to be at an unfair disadvantage.

Yet these and other objections have always to face the fact that these tests when applied to school children do actually correlate highly with general intelligence as estimated by the teachers. This estimate is itself no doubt very far from infallible, and may often be influenced, even more than it should be, by the position of the children as regards school marks. But it is surely no small thing if a psychologist with a few simple tests can, in a few hours, give as fair an estimate of the correct order of a class as

[1] Cf. W. James, *Principles of Psychology*, Vol. I., p. 423. "Geniuses are commonly believed to excel other men in their power of sustained attention. . . . But it is their genius making them attentive, not their attention making geniuses of them."

regards their general intelligence as can be given by a teacher who has known them and worked with them for a year or more.

Perhaps the most serious criticism of the tests has yet to be named—viz. that the results gained by different investigators with the same tests have sometimes shown serious divergences. For the present the most important task is an inquiry into the cause of such variations, the selection of those tests which give the highest and most constant correlations with intelligence and for which exact and definite instructions can be most easily given, and the standardisation of these tests so that they can be applied by different persons, in different schools, and at different times, in exactly the same way, as far as this is possible in operations into which some human element necessarily enters.

THE BINET TESTS OF GENERAL INTELLIGENCE.[1]

A fitting conclusion to this chapter may be formed by a brief account of some tests which have become famous not only in the country in which they originated, namely France, and in other countries on the Continent, but in this country and in America. I refer to tests devised by Professor Binet, some of whose work we have already studied, and Dr. Th. Simon. They conceived the plan of drawing up a list of simple questions exactly appropriate to the average child of three years old, a second set appropriate to children of four years old, and so on. After

[1] Throughout the discussion of the Binet tests the reader may substitute for the term "general intelligence" the words "degree of average mental development" or "mental age."

the application of these questions to large numbers of French children, they were able to arrange the questions so that, as a rule, most of the children of a given age succeeded in passing the test by answering at least four out of the five questions designed for that age. Usually the majority of children of the given age passed the test, a few failing in the tests for their age, while a few also succeeded in the test intended for children a year or two older.

Test for Children Three Years of Age.—For example, the following were the tests given to three-year-old children.

1. Point to their eyes, nose, mouth, elbow.
2. Repeat a sentence of six syllables.
3. Repeat two non-consecutive digits, thus 9 . . . 7. They should be pronounced slowly.
4. "What is your name?" Surname must be given.
5. The child is shown pictures and asked "What do you see there?" He should be able to recognise and name simple objects. Only older children give a *description* of the pictures, referring to the action, etc.

Advantages of the Binet Tests.—Such tests have some advantages over the type of intelligence test we have just described previously. In the first place, they lend themselves more obviously to grading according to years. Secondly, they are perhaps more readily applied, though the difficulty of applying the Binet tests must not be underestimated. Great care must be taken to put the child completely at his ease before the tests are given and not to discourage him by telling him when he gives wrong answers. On the other hand, equal care must be taken to avoid helping the child by the slightest degree of suggestion,

except when help for the understanding of the question itself may be desirable.

In reply to those who question the capacity of an intelligent teacher to apply these tests fairly satisfactorily without prolonged psychological training, one may at least point out that teachers are continually forming opinions as to the general capacity of their pupils, and they are hardly likely, at the least, to do it *less* satisfactorily with the aid of the Binet tests so long as they keep in view the limitations of the tests and interpret the results with caution.[1]

Especially must it be remembered that the tests can only give a rough and comparative estimate of the *average* capacity of the child. As regards capacity for any special work he may be behind or beyond the majority of the children of the age with which he is classed.

The Influence of Training.—Against the advantages of the Binet tests mentioned must be put the great difficulty of avoiding the results of special training and information. Take, for example, the question for the three-year-old children, "What is your name?" the surname being particularly required. It is easy to see that definite instruction on such a point might enable a child to pass the test, when an equally intelligent child of the same age might fail through lack of such definite instruction on the part of his parents.

Of course no one claims that success in any of the Binet tests is independent of experience and training. The principle underlying the system is that the experience

[1] As to the great differences between different teachers in respect to their usual ways of estimating the intelligence of their pupils see Binet, "Nouvelles Recherches sur la Mesure du Niveau Intellectuel chez les Enfants d'Ecole," *L'Année Psychologique*, Vol. XVII., p. 169.

necessary for the tests of any given age is of a very general nature, so general, indeed, that *every* child will have had such experience by the time he reaches the given age. The more backward children, however, have not sufficient native intelligence to take advantage of their experience as the brighter children do.

Modification of the Tests for English-speaking Children.—It must be remembered that the tests were devised for French children. Extended experiments in this country and America suggest that the tests for the younger children, up to six and perhaps seven years of age, are too easy on the average for English-speaking children, while some of the tests for older children are too difficult.

The arrangement of tests of which I have been speaking is known as the Binet-Simon tests of 1908. Binet and Simon themselves drew up in 1911 a revised list of the tests, and it is this arrangement which I have chiefly followed below. I have, however, taken into consideration the experiments of other investigators (especially English and American) with the Binet tests; and occasionally, when there is good evidence that the tests should be assigned to a different age, at least for English-speaking children, I have made some rearrangement. But in every such case the year to which Binet finally assigned the test is given in brackets after the test.

The tests are given for the years from four to nine, as these are the years at which rapid estimations of the general intelligence of children are most frequently likely to be needed; for example, when the children are beginning their school life or entering a new school. Further, as already mentioned, there is a very considerable agreement among recent investigators that many of the later tests are too difficult for the ages to which they are assigned, and

the moving onward of such tests to later years would leave us with gaps unfilled. In time, no doubt, satisfactory substitutes will be found for these unduly difficult tests in the middle years.

We have already seen some reason to believe that the average child of the upper middle classes has more native intelligence—apart from the results of better training—than the average child of the working class. Thus it is not surprising that the Binet tests give different results according to the social standing of the children tested. But even when this is allowed for, there seems to be some difference of opinion among various investigators as to the relative placing of some of the questions. This may be due to one of two things: (i) either success in these particular tests may be determined largely by the individual environment of the child—in which case children in different countries, or in different social ranks, would respond differently to the tests; (ii) or success in these tests is peculiarly liable to be affected by the manner in which the tests are given, in which case different investigators would be likely to get different results even when applying the tests to children of the same country and of the same social standing.

It should be noted too that variation of the mode of putting the questions due to the different languages used may be considerable.

It thus appears that much more work is needed before a system of tests can be drawn up of universal validity. But the reader will probably desire to apply the tests upon a group of children in the same school, belonging roughly to the same social class. In such cases, even supposing the tests of any given year are too easy or too hard for the children of that year, the teacher can at least apply a *comparative* test. Those children who do much worse at the

given tests than the average are very likely to be among the dullards, while those who do best at the tests and succeed in tests meant for ages a year or two beyond them are very probably the brightest among the children tested.

Finally, though, as at present constituted, these tests cannot be expected to give very exact estimates of intelligence, their application is likely at least to give the teacher a valuable insight into the minds of the children tested; and this not only by the records of success or failure in the various tests, but also by the manner in which the children tackle the problems.

Binet's Intelligence Tests.[1]

Four Years of Age.—(1) Show the child a closed penknife, and ask "What is this?" Do the same with a penny, and a key. All should be answered correctly.

(2) Ask the child to repeat after you, (i) 639, (ii) 592. Pronounce the figures slowly.

(3) Draw a square about an inch long and ask the child to copy it, with pen and ink. Let him make three copies. Two at least should be free from bad curves and overlapping ends. Thus A, B and C should be rejected, but D and E passed. (See Fig. 10.) [Five years.[2]]

(4) Put four coins on the table and ask the child to count them. (Five years.)

[1] My thanks are due to Dr. Th. Simon for permission to reproduce copies of the pictures and diagrams.

[2] The age stated in brackets after some of the tests indicates the age for which Binet suggests the test in his 1911 scheme, unless 1908 is explicitly mentioned. The questions have not been moved from the year to which Binet assigned them unless there is considerable evidence that the change fits them better for English-speaking children.

(5) Draw a line of 5 cm. and one of 6 cm. parallel to one another, about 3 cm. apart, and say to the child, "Tell me which is the longer of these two lines."

One investigator suggests that we should say "longest," this being what the child would probably say himself.

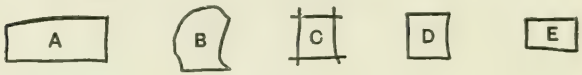


Fig. 10.

Five Years of Age.—(1) "Which of these two is the prettier?" Three pairs of drawings such as those given below are to be used. Show them one pair at a time and do not point to either face. (Six years.)

(2) "Which of these two boxes is the heavier?" Small boxes of the same shape and size, but containing different quantities of shot or other material, should be used. The weight of the pairs should be as follows:—

3 grams and 12 grams,[1]
6 grams and 15 grams.

Place a pair of the boxes about three inches apart on a table in front of the child. The main point here is to note whether the child knows how to set about estimating and comparing weights.

(3) "Is it morning or afternoon?" (Six years.)

(4) Repeat a sentence of ten syllables. Three chances should be given if necessary, with a new sentence each time.

Suggested examples: "If you go out be sure to take your coat." "When Spring comes the birds will sing in the trees."

(5) Procure two oblong pieces of cardboard of equal

[1] 1 gram = 15·4 grains, approximately.

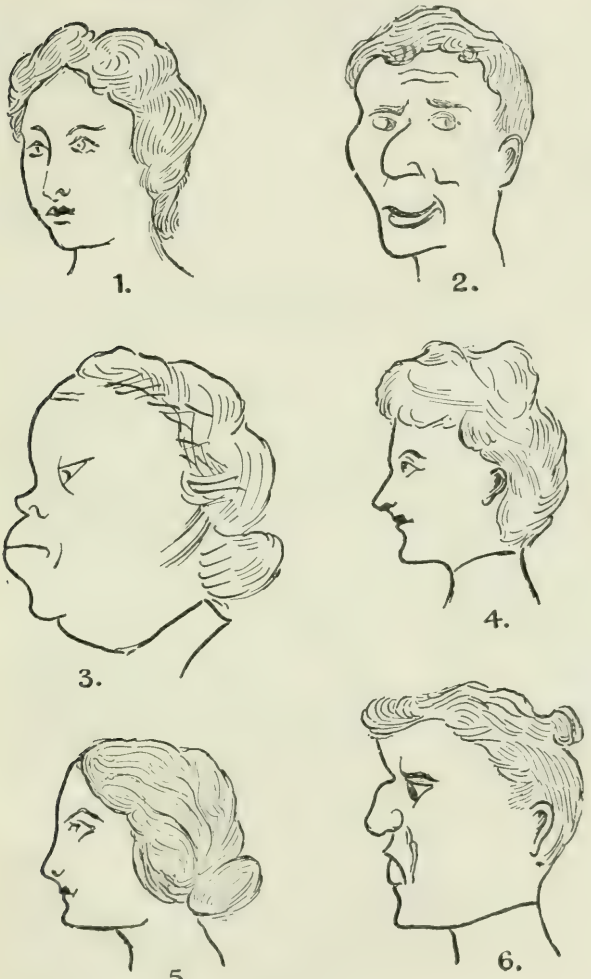


Fig. 11.

size. Cut one oblong diagonally. Place the two triangles thus obtained near the other oblong on the table thus:

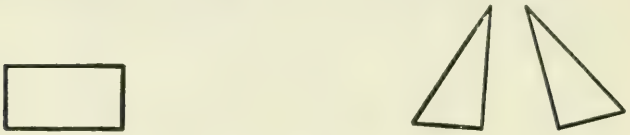


Fig. 12.

Say, "Put these two cards together," pointing to the triangles, "so that they make a figure like this," pointing to the oblong.[1]

Six Years of Age.—(1) Say to the child, "Here is a key. I want you to put it on that chair. Then shut the door. Then on the chair near the door you will see a box. Bring me that box. Now listen again . . . first put the key on this chair, then shut the door, then bring me the box." All three orders must be executed and in the correct order. This is a test in which much will evidently depend on the clearness of the directions. (Seven years.)

(2) "What colour is this?" Show red, yellow, blue and green. No failure must be allowed. (Seven years.)

(3) "What is (i) a fork, (ii) a table, (iii) a chair, (iv) a horse?" Definition by usage should be possible at this age, *e.g.* a fork is to eat with; a chair is to sit on. At a later stage definition by classification and by enumeration of qualities begins. Younger children are frequently content with the repetition of the word, thus "What is a

[1] Two investigators put this test at four years; one, with Binet, at five years; two others put it at six years. This divergence may be due to the different ways in which the triangles may be placed. When placed as in Fig. 12 one triangle has to be turned over to accomplish the test. See Winch, *Child Study*, Vol. VII., No. 3.

fork?" "A fork." At least three definitions out of five should give something more than this.

(4) The child should repeat a sentence of sixteen syllables. One out of three sentences to be repeated correctly. (1908.)

(5) Place thirteen pennies before the child and ask him to count them aloud, and to point to each penny as he counts it. No error should be made.

Seven Years of Age.—(1) "Show me your right hand." "Show me your left ear."

Binet found that practically every four-year-old child pointed to his right ear after having pointed to his right hand, while one in three of the five-year-olds made a mistake.

(2) Place three pennies and three halfpennies on the table. Say to the child, "Suppose I were to give you all these how much would you have in halfpence altogether?"

(3) "Look at this face. What is left out?" The

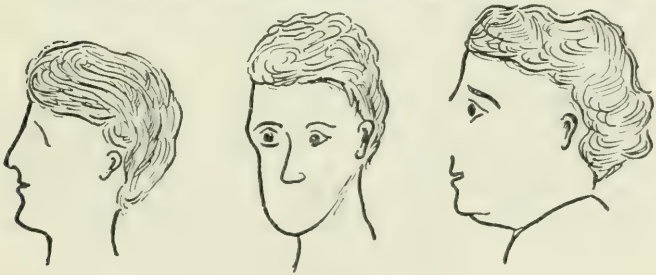


Fig. 13.

test is passed if two out of three are done correctly. (Eight years.)

(4) Description of a picture.

A set of half a dozen pictures should be procured; they

should be "story" pictures, not mere landscapes. The child is to be asked, "What do you see in this picture? Tell me what it is about." Four- and five-year-old children usually mention individual objects. At six or seven description proper begins, with reference to what people are doing. This test is passed if the child gives something more than a mere enumeration of objects in one of the pictures.

(5) The child is required to copy accurately with pen and ink a diamond shape. Binet accepted figures 1, 2 and 3 below, but not figures 4, 5 and 6. (Six years.)

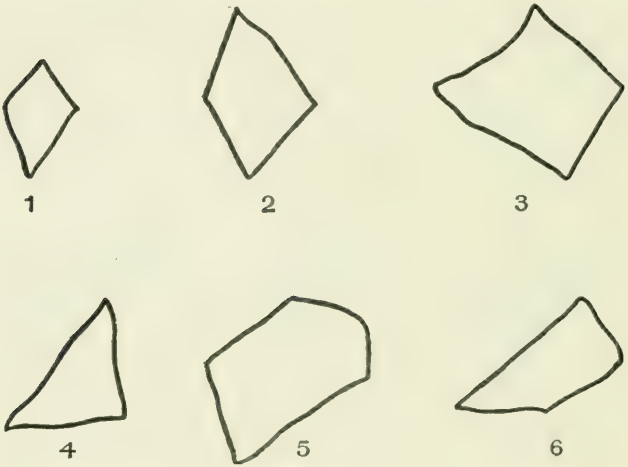


Fig. 14.

Eight Years of Age.—(1) Comparison from memory. "You know what a fly is?" "Yes." "And you know what a butterfly is?" "Yes." "Are they the same?" "No." "Well, what is the difference between them? How

can you tell them apart?" There should be real comparison in at least two out of three pairs of objects suggested. The two objects for comparison must be quite familiar to the child. Other pairs suggested: milk and water, cloth and paper.

(2) "Count from twenty backwards to nought." If necessary start the child with 20, 19, 18.

The counting should be completed within twenty seconds.

(3) Dictation of a simple phrase, such as "The pretty little girls." This must be written sufficiently correctly and legibly to be read by a person who did not know what was to be written. (1908.)

(4) Ask the child (i) the day of the week, (ii) the month, (iii) the day of the month, (iv) the year. Allow an error of three days either way in the day of the month. Failure is most common with respect to the year. Some younger children tested by Binet had actually been especially trained by daily practice in giving such dates and days, yet failed utterly in this test, showing the uselessness of premature instruction.

(5) Repeat five figures, *e.g.* 79235.

Nine Years of Age.—(1) Ask for definitions of common objects, as in question 3 for six-year-olds. By now the children should give something more than mere usage; *e.g.* instead of saying that a horse is "for drawing carriages" the classification of horse under animal may be given, thus "a horse is an animal that draws carriages," or a description may be given.

(2) Play at "shop" with the child. Provide yourself with a shilling and give him four pennies, eight halfpennies, a threepenny and a sixpenny piece, a shilling, florin, and half-crown.

Price an article at fourpence, and handing your shilling

ask for change. The test is passed if the correct change is given.

(3) "Tell me the names of all the months in order." One error of omission or misplacement may be allowed.

(4) Place on the table, in haphazard order, a halfpenny, penny, threepenny piece, sixpence, shilling, florin, half-a-crown, a ten-shilling piece and a sovereign. Ask the child to name these. A confusion between the florin and the half-crown or between the ten-shilling piece and the sovereign may be passed over, but not the invention of a new piece, *e.g.* three shillings or fifteen shillings.

(5) Easy problem questions.

(i) "What should you do when you miss a train?" Good answer, "Take the next." Bad answers, "Run after it," "Go home," "Buy a ticket."

(ii) "What should you do when you break something which does not belong to you?"

(iii) "What should you do if a boy you are playing with hits you without meaning to?"

Two sensible answers may be regarded as satisfactory.

The Method of Scoring.—Suppose it is desired to test a child of six years of age. The investigator should first apply the tests prescribed for children five years of age. Success in these will give the child confidence. If he fails to pass the test, *i.e.* answers less than four out of five questions, the tests for children still a year younger should be applied.

Suppose, however, the child passes the five-year-old test satisfactorily, he should proceed to the six-year-old test. If this is passed, or if any question in this is answered correctly, the test for seven-year-olds should be used, and so on until a test is reached in which the child answers none of the questions for that year.

Even the child who has failed in the five-year-old test and who had to go back to the four-year-old test should subsequently be given the six-year-old test, then the seven-year-old test, and so on, until a test is reached in which the child answers none of the five questions.

If a child of five passes the test for five-year-olds and also the test for six-year-olds, his "mental age" is said to be six years, *i.e.* he is a year ahead of the average.[1]

Further, a year of mental age is added for every five questions beyond the test which the child just succeeds in passing. Thus if this child of five answers five questions beyond those intended for six-year-old children (as well as passing the six-year-old test) he is to be reckoned as mentally seven years old, even if he does not succeed in answering four questions in the seven-year-old test.

Occasionally a child may fail in the test for his own year but pass in that for children a year older. In accordance with the rule just given, suppose a six-year-old child passes the test for five years, but answers only two of the questions in the six-year-old test. This should make him "mentally" five years old. But if he also answers four questions in the seven-year-old test, then these four added to the two questions answered in the six-year-old test give him another year, *i.e.* his mental age is five + one = six years.

Binet suggests a further refinement of scoring. Suppose a child passes the four-year-old test satisfactorily: this gives him, as a start, the mental age of four. But for every question which the child answers beyond the four-year-old test Binet would add one-fifth of a year. Thus if he answers one question in the five-year-old test and one in

[1] Strictly speaking one should perhaps say that his mental age is six-and-a-half years, as that would be the average age of the six-year-olds for whom the tests are supposed to be exactly suitable.

the six-year-old test he adds two-fifths to his mental age, which thus becomes 4·4 years.

An objection, however, to such a refinement in the arrangement of the children is that it suggests an exactness of measurement by the Binet tests which they are scarcely justified in claiming.

For the Binet tests for later years and for full information as to their application see articles by Binet and Simon, *L'Année Psychologique*, Vol. XIV. (1908), and by Binet, *ibid.*, Vol. XVII. (1911); also Whipple, *Manual of Mental and Physical Tests*, p. 473, and Winch, *Child Study*, Vol. VI., No. 8, Vol. VII., Nos. 1, 2, 3, 4, etc.

For more recent developments of mental tests see Terman, *The Measurement of Intelligence*, and Ballard, *Mental Tests*.

BIBLIOGRAPHY.

This little book stands at the parting of two ways, one leading to what we may call pure experimental psychology and a second leading to experimental pedagogy. References are given below for further reading (in English only) in both these sections.

I. "PURE" EXPERIMENTAL PSYCHOLOGY.

The student would be well-advised to begin with C. S. Myers's *Introduction to Experimental Psychology*, and subsequently he may pass on to the same author's *Text-book of Experimental Psychology*. This contains a concise account of the main results of experimental psychological research in practically all its branches. The book requires for its proper appreciation a good knowledge of general psychology and some knowledge of the physiology of the nervous system.

In E. B. Titchener's *Experimental Psychology, Qualitative and Quantitative* (4 vols.) the reader will find an elaborate discussion of the methods of experiment.

Experimental Psychology and Culture, by G. M. Stratton, is a very readable collection of essays on leading topics.

The Economy and Training of Memory, by H. J. Watt, is based largely upon experimental results, and is suitable for beginners.

The Experimental Psychology of Beauty, by the present writer, is intended for beginners, and includes accounts of a number of experiments upon school children.

II. Experimental Psychology bearing more directly upon Education, and Experimental Pedagogy.

Whipple's *Manual of Mental and Physical Tests* is a mine of information both as to methods and results. Indeed its very fulness is apt to confuse the beginner.

Claparède's *Experimental Pedagogy and the Psychology of the Child* gives a general discussion of problems and methods together with a special treatment of fatigue.

Schulze's *Experimental Psychology and Pedagogy* (translated by Pintner) is valuable chiefly for its many illustrations of apparatus, photographs, diagrams, etc.

R. R. Rusk's *Introduction to Experimental Education* gives an account of the main results gained in experimental pedagogy.

Thorndike's *Educational Psychology* deals especially with the statistical aspect of the subject.

Those mathematically inclined will find the theory and methods of correlation fully dealt with in William Brown's *Essentials of Mental Measurement*.

The student is strongly recommended to proceed as soon as possible to the reading of original papers on topics of special interest to him. He will probably find many of

these no more difficult than the reading of text-books and he will also gain thus a deeper insight into methods of research. Such papers upon topics of immediate interest to school teachers or students of educational psychology are to be found in the following journals:—

The Journal of Experimental Pedagogy, The British Journal of Psychology, and *The Journal of Educational Psychology.*

Below are given a number of articles from these journals bearing upon topics dealt with in this book, in addition to those already mentioned in the text.

Association and Imagery (Chaps. I. and II.).

R. R. Rusk, "Experiments on Mental Association in Children," *Brit. Journ. of Psych.*, Vol. III.

Economical Methods of Learning (Chap. V.).

W. Pyle and J. Synder, "The Most Economical Unit for Committing to Memory," *Journ. of Educ. Psych.*, Vol. II.

Correlation (Chap. VIII.).

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P. B. Ballard, "Obliviscence and Reminiscence," *Brit. Journ. of Psych.*, Monograph Supplements, II.

The Improvement of the Memory (Chap. IX.).

W. H. Winch, "The Transfer of Improvement in Memory in School Children," *Brit. Journ. of Psych.*, Vols. II. and III.

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J. H. Wimms, "The Relative Effects of Fatigue and Practice produced by Different Work," *Brit. Journ. of Psych.*, Vol. II.

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TESTS FOR GENERAL INTELLIGENCE (Chap. XII.).

B. Hart and C. Spearman, "General Ability: Its Existence and Nature," *Brit. Journ. of Psych.*, Vol. V.

S. Wyatt, "The Quantitative Investigation of Higher Mental Processes," *Brit. Journ. of Psych.*, Vol. VI.

W. H. Winch, "Some New Reasoning Tests suitable for the Mental Examination of School Children," *Brit. Journ. of Psych.*, Vol. VII.

C. Burt, "The Development of Reasoning in School Children," *Journ. of Exp. Ped.*, Vol. V.

THE BINET TESTS.

In the *Journ. of Educ. Psych.* articles by Huey (Vol. I.), Terman and Childs (Vol. III.); in the *Journ. of Exp. Ped.*, by K. Johnston (Vol. I.) and B. Dumville (Vol. II.).

Rogers, Agnes L., and McIntyre, J. L., "The Measurements of Intelligence in Children by the Binet-Simon Scale," *Brit. Journ. of Psych.*, Vol. VII.

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